STATE OF TENNESSEE
DEPARTMENT OF
ENVIRONMENT AND CONSERVATION
QUALITY MANAGEMENT PROGRAM
FINAL
QUALITY ASSURANCE PROJECT PLAN (QAPP)
for
106 Monitoring
in the
DIVISION OF WATER POLLUTION CONTROL
Volume I

TDEC EFFECTIVE DATE: FEBRUARY 2010
VERSION NO. 6

PART A

PROJECT MANAGEMENT

A1 QUALITY ASSURANCE PROJECT PLAN

TITLE AND APPROVAL SHEET

DOCUMENT TITLE	Quality Assurance Project Plan (QAPP) for 106 Monitoring (Volume I – 305(b) and 303(d) assessments, TMDL monitoring, and ecoregion reference monitoring)
ORGANIZATION TITLE	Tennessee Department of Environment and Conservation, Division of Water Pollution Control
PREPARED BY	Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Planning and Standards Section
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DIVISION QAPP PROJECT MANAGER	Garland Wiggins
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PLAN COVERAGE	General instructions for the collection of water quality data for 305(b) and 303(d) assessments, ecoregion reference monitoring, and TMDL development.

PEER REVIEW

As a part of the internal review process, the following individuals reviewed this document.

Reviewers Name	Title	Program
Tennessee Department of Environment and Conservation Division of Water Pollution Control		
Paul E. Davis	Director	Water Pollution Control
Garland Wiggins	Deputy Director	Water Pollution Control
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Rebecca James	Environmental Specialist 3	CO PAS
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Denise Goddard	EPA Region $ Chemist, Quality Assurance Section	EPA Region 4

APPROVALS AND CONCURRENCES

Approvals. This is to certify that we have reviewed this document and approve its contents.

Signature
Marilyn Thornton, QA Manager
EPA Region 4
Date

Signature
Forrest Leedy, 106 Project Manager
EPA Region 4
Date

Signature
Paul Sloan
Deputy Commissioner of Environment
Tennessee Department of Environment and Conservation
2/03/06
Date

Signature
Paul E. Davis
Director of Water Pollution Control
Tennessee Department of Environment and Conservation
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Date

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Deputy Director of Water Pollution Control
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Charles L. Head
Health & Safety/Quality Management Director
Tennessee Department of Environment and Conservation
2/10/06
Date

Concurrences and Reviews. The following staff in the Division of Water Pollution Control participated in the planning and development of this project:

Kimberly J. Sparks — 2/13/2006
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Kimberly J. Sparks
Biologist III
Tennessee Department of Environment and Conservation

Deborah H. Arnwine — 2/13/06
Signature — Date
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Gregory M. Denton — 2/15/06
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Gregory M. Denton
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2/15/06
Signature — Date
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Tennessee Department of Environment and Conservation

Garland P. Wiggins — 2/9/06
Signature — Date
Garland P. Wiggins
Deputy Director
Tennessee Department of Environment and Conservation

TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION
QAPP FOR 106 MONITORING
VOLUME I

A2 TABLE OF CONTENTS, REVIEW PROCESS AND EVALUATION

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APPENDICES

TDEC QUALITY ASSURANCE PROJECT PLAN
FOR 106 MONITORING
REVISIONS AND ANNUAL REVIEW

1. This document shall be reviewed annually to reconfirm the suitability and effectiveness of the program components described in this document.

2. A report of the evaluation of effectiveness of this document shall be developed at the time of review and submitted to appropriate stakeholders. Peer Reviews shall be conducted, if necessary and appropriate. It shall be reconfirmed that the document is suitable and effective. It shall include, if necessary, clarification of roles and responsibilities, response to problem areas and acknowledgement of successes. Progress toward meeting Tennessee Department of Environment and Conservation (TDEC) mission, program goals and objectives shall be documented. Plans shall be made for the upcoming cycle and communicated to appropriate stakeholders.

3. The record identified as "Revisions" shall be used to document all changes.

4. A copy of any document revisions made during the year shall be disseminated to all appropriate stakeholders. A report shall be made to the Deputy Commissioner of any changes that occur. Other stakeholders shall be notified, as appropriate and documented on the "Document Control" sheet.

NOTICE OF REVISION(S) RECORD

Date	Section/Page Draft Version 1	Section/ Page Version 3	Revision Type	Revision Description
07/13/05	Throughout document	Throughout document	Minor	Acronyms were defined at first reference in document.
07/13/05	A4.2.1.A/Page 18	A4.2.1.A/ Page 18	Minor	Radon Program Manager was removed from the list of environmental managers.
07/13/05	A4.2.1C/Page 19	A4.2.1 C/ Page 21	Minor	Changed wording of sentence.
07/13/05	A6.1/Page 25	A6.1/Page 28	Minor	Reversed sentence order.
07/13/05	A6.1 1./Page 27	A6.1 1./ Page 33	Minor	Changed "Waters" to "Waterbodies".
07/13/05	A6.1 1./Page 28	A6.1 1./ Page 33	Minor	Added the word macroinvertebrate.
07/13/05	A6.1.1/Page 31 Table 8	A6.1.1/Page 34	Major	Changed table for surface water sampling.
07/13/05	A6.1 2./Page 27	A6.1 2./ Page 35	Minor	Removed the last word, TMDLs, from the last sentence of the paragraph.
07/13/05	A6.1 3./Page 27	A6.1 3./ Page 35	Minor	Changed semi-quantitative to Semi-Quantitative Single Habitat.
07/13/05	A6.1.6/Page 33	A6.1.3/Page 36	Minor	Clarified the section of QSSOP with QC requirements.
07/13/05	A7.2 Step 2 c./ Page 41	A7.2 Step 2 c./Page 45	Minor	Reversed wording in sentences.
07/13/05	A7.2 Step 5 a./ Page 42	A7.2 Step 5 a./ Page 45	Minor	Revised wording on 3,4, and 5.
07/13/05	A7.2 Step 5 b./ Page 42	A7.2 Step 5 b./ Page 46	Minor	Removed "Type of data used (from list)".
07/13/05	A9.1 /Page 59	A9.1/Page 62	Minor	Added the word "Form".
07/13/05	A9.3/Page 60	A9.3/Page 62	Minor	Changed wording to clarify analyses turn around times.
07/13/05	A9.4.A/Page 60	A9.4.A/ Page 63	Minor	Changed wording to "provide required laboratory documentation".
07/13/05	A9.4.B/Page 61 Table 16	A9.4.B/Page 63 Table 16	Minor	Specified which manifest and chain of custody sheets.
07/13/05	A9.7/Page 61	A9.7/Page 64	Minor	Removed the specific version of ADB used.
07/13/05	A9.8/Page 62	A9.8/Page 65	Minor	Specified that the WQDB is backed up nightly.
07/13/05	A9.8/Page 62 Table 17	A9.8/Page 65	Minor	Specified the title of forms.

Date	Section/Page Draft Version 1	Section/ Page Version 3	Revision Type	Revision Description
07/13/05	B1.1/Page 64	B1.1/Page 67	Minor	Deleted part of the sentence beginning "The Division".
07/13/05	B1.3.A Year 5/ Page 67	B1.3.A/Page 69	Minor	Reworded to "public notices are released".
07/13/05	B1.4/Page 71	B1.4/Page 72	Minor	Specified laboratories used.
07/13/05	B1.4 4./Page 73	B1.4 4./ Page 76	Minor	The word "readings" was changed to "measurements".
07/13/05	B1.8.C/Page 83 & Table 25/Page 84	B1.10.C/Page 90 & Table 25/Page 91	Major	Updated parameters needed for TMDLs.
07/13/05	B1.8.C 3./Page 88	B1.10.C/ Page 94	Minor	Clarified wording.
07/13/05	B1.9/Page 91 Table 29	B1.11/Page 97 Table 29	Minor	Removed sentence from table footnote.
07/13/05	B2.1.3/Page 94	B2.1.3/ Page 100	Minor	Clarified where meters are calibrated.
07/13/05	B2.1.5/Page 95	B2.1.5/ Page 101	Minor	Clarified how bacteriological samples are collected and where additional information can be found.
07/13/05	B2.7/Page 98	B2.7/Page 104	Minor	Specified where additional water safety cautions may be found.
07/13/05	B3.1/Page 98	B3.1/Page 104	Minor	Added the title of the laboratory chain of custody.
07/13/05	B3.1 & 3.2/Page 99	B3.1 & B3.2/ Page 104-105	Minor	Specified which laboratories are secured facilities.
07/13/05	B3.2/Page 99	B3.2/Page 105	Minor	Added a sentence that lists paperwork sent to WPC.
07/13/05	B3.2/Page 99	B3.2/Page 105	Minor	Clarified wording on first sentence in 4th paragraph.
07/13/05	B3.4/Page 100	B3.4/Page 106	Minor	Changed wording of the last sentence in the 1st paragraph.
07/13/05	B3.5/Page 100	B3.5/Page 107	Minor	Changed wording of the last sentence in the 1st paragraph.
07/13/05	B4.8/Page 104	B4.8/Page 110	Minor	Removed nonstandard method reference.
07/13/05	B6.4/Page 111	B6.4/Page 116	Minor	Clarified wording of last sentence in 1st paragraph.
07/13/05	C1.1/Page 119	C1.1/Page 125	Minor	Reworded the 1st sentence of the 1st paragraph.
07/13/05	D1.5/Page 130	D1.5/Page 136	Minor	Specified where QC procedures are describes.
07/13/05	D2.1/Page 130	D2.1/Page 136	Minor	Clarified the 1st sentence of the 1st paragraph.

Date	Section/Page Draft Version 1	Section/ Page Version 3	Revision Type	Revision Description
02/06/06	A6.1 1./Page 27	A6.1 1./ Page 30	Minor	Removed description of high quality water.
02/06/06	A6.1 4./Page 27-28 A6.1.1 3./Page 30	A6.1 4./ Page 30-31 A6.1.1 3./ Page 33	Minor	Biological samples are not needed for 303(d) waters listed only for pathogens.
02/06/06	A7.3 /Pages 49-51 Table 14	A7.3/ Page 52-54 Table 14	Minor	Standard Methods, 19th Edition is the SOP for pathogen analyses only.
02/06/06	B1.4 1./ Page 71	B1.4/Page 74	Major	Changed procedure for determining high quality waters.
02/06/06	B1.4 5./Page 75-76	B1.4 5./ Page 77-82	Major	Revised monitoring for 303(d) Listed Waterbodies. Replaced Table 21 with new monitoring requirements and removed Draft Table 22.
02/06/06	B1.4 6./Page 77 Table 23	B1.4 6./ Page 82 Table 22	Major	Draft Table 23 was renumbered to Table 22.
02/06/06	B1.4/Page 78 Table 24	B1.6/Page 85 Table 24	Minor	Added SQSH sample type to 303(d) and watershed monitoring.
02/06/06	B1.8 C/ Page 86 Table 27	B1.10/Page 94 Table 27	Minor	Added SQSH as core monitoring activity for 303(d) monitoring.
02/06/06	B2.3.1 a./Page 94	B2.3.1 a./ Page 102	Minor	EFO WPC Manager or their designee may be contacted if a sample cannot be collected as scheduled.
02/06/06		Throughout document	Minor	Revised workplan fiscal year to 2006 and publication date to 2005.
02/06/06		Throughout document	Minor	Revised 303(d) from Proposed to Final 2004.
02/07/06	A6.1/Page 29	A6.1/Page 31	Minor	Added fish tissue monitoring description.
02/07/06	A6.1.1/Page 30	A6.1/Page 33	Minor	Long term monitoring expected measurements added.
02/07/06	A7.2 b./Page 41	A7.2 b.10./ Page 44	Minor	Added description of postings due to fish tissue contamination.
02/07/06	B1.4 1./Page 71	B1.4 1./ Page 74	Major	Revised antidegradation monitoring section.
02/07/06	B1.4/Page 77	B1.4 7./Pages 82-84 Table 23	Major	Added fish tissue monitoring section and new Table 23 list of monitoring stations.
02/07/06	B1.9/Page 88 Table 29 Appendix D/ Pages 156-157	B1.11/Page 96 Table 29 Appendix D/ Page 164-166	Major	Nutrient MDLs have changed.
02/07/06	B2.1.1/Page 92 References/	B2.1.1/ Page 100	Minor	Added fish tissue collection protocol reference.

Date	Section/Page Draft Version 1	Section/ Page Version 3	Revision Type	Revision Description
	Page 140	References/ Page 148		
02/07/06	B5.3/Page 104	B5.3/Page 112	Major	Added QC requirements for fish tissue collection and processing.
02/07/06		Throughout Document	Minor	Numerous employees, positions, and titles have changed. These are not individually documented.
02/08/06	B1.4 4./Page 74 Table 20	B1.4 4./ Page 77 Table 20	Major	Changed COD to CBOD
02/09/06	B6.3/Page 37	B6.3/Page 40	Minor	Updated budget figures.
5/02/06		B1.4/Page 76 Table 18	Minor	Updated minimum TMDL requirements.
5/2/06		B1.10.C/Page 93 Table 25	Minor	Added TOC to nutrient TMDL.
6/21/06		A6.1.1/Page 34 Table 8	Minor	Added cyanide to long term monitoring parameters

This revision(s) has been reviewed and approved. This revision(s) becomes effective on: February 15, 2006.

This revision(s) has been reviewed and approved. This revision(s) becomes effective on: February 15, 2006.

2/9/06

Paul E. Davis
Director
TDEC Division of Water Pollution Control

2/10/06

Charles L. Head
Health and Safety/Quality Assurance Director
Tennessee Department of Environment and Conservation

2/18/06

Paul Sloan

Date	Section/ Page Draft Version 4	Revision Type	Revision Description
02/27/07	Throughout Document	Minor	Numerous employees, positions, and titles have changed. These are not individually documented.
2/27/07	Appendix G	Minor	Deleted Appendix G, added names to Peer Review list
2/27/07	Throughout Document	Minor	Corrected dates of benthic SOP, workplan and 303dlist
2/27/07	A. Table 11	Minor	Updated Deliverable Due Dates
2/27/07	A. 9.8 Table 17	Minor	Added data types
2/27/07	B.1.6 Table 24	Minor	Added more projects
2/27/07	B.1.11	Major	Relocated B1.11 and Table 29 to B4.
2/27/07	D	Major	Major rewrite of D
2/28/07	A6.1.4	Major	Added equipment list for monitoring
2/28/07	A6.	Minor	Combined 2 paragraphs about fish tissue monitoring and advisories
3/1/07	A6.1.3	Minor	Regulatory Criteria Added sentences about criteria
3/1/07	B1.4	Minor	Added frequency info to monitoring types.
3/1/07	B.1.4	Minor	Added parameter list for fish tissue analysis.
3/1/07	B.1.9	Minor	Added sentence about the location of stations.
3/1/07	B2.1.2	Minor	Added sentence about sampling equipment
3/1/07	B4.2	Minor	Updated info on turnaround time for results.
3/1/07	B5.1	Minor	Added sentence about QC failures.
3/1/07	B7.1	Minor	Listed meters used in sampling. Added info on calibration of standards and equipment.
3/1/07	B.7.2	Minor	Added info on calibration of standards and equipment.
3/1/07	B8.1	Minor	Added info about acceptance criteria.
3/1/07	B10.3	Minor	Added software info for Data Analysis

Date	Section/ Page Draft Version 4	Revision Type	Revision Description
3/2/07	Appendix	Minor	Corrected staff on lab org chart
3/13/07	A.9.3	Minor	Corrected turnaround time for lab results.
3/26/07	A.6-1	Minor	Updated project info
3/26/07	A7.1	Minor	Corrected protocol info
3/26/07	A.7.2	Minor	Typo
3/26/07	A7.3	Major	Major rewrite and additions
3/26/07	B.2	Minor	Clarified objectives
3/26/07	B.2-1	Minor	Revised wording for protocols
3/26/07	B-2.3-4	Major	Moved to section D-2
3/26/07	B.2.5	Minor	Table 31 Flag key moved to Section D-2
3/26/07	B.2.6	Minor	Renumbering
3/26/07	B.3.4	Minor	Added info about chain of custody.
3/26/07	B.3.6	Minor	Corrected protocol letters.

Date	Section/ Page Draft Version 4	Revision Type	Revision Description
3/26/07	B.4	Minor	Added method info
3/26/07	B.4 Table 29 and 33	Minor	Changed table numbers
3/26/07	B.4.2	Major	Added equipment and instrumentation, analytical methods and instruments
3/29/07	B.8	Major	Added data about supplies and consumables.

This revision(s) has been reviewed and approved. This revision(s) becomes effective on: April 15, 2007.

Paul E. Davis
Director
TDEC Division of Water Pollution Control

4/2/07
Date

Charles L. Head
Health and Safety/Quality Assurance Director
Tennessee Department of Environment and Conservation

4/02/07
Date

David Draughon
Senior Director for Water Resources Group
Tennessee Department of Environment and Conservation

3/30/07
Date

Date	Section/Page Draft Version 5	Revision Type	Revision Description
9/25/08	Throughout document	Minor	Employee names and positions updated
9/25/08	Appendix B	Minor	Employee names and positions updated
9/25/08	Appendix	Minor	Took out station check form – not being used
9/25/08	A6.1 p.38	Minor	Updated # of stations to be monitored
9/25/08	Throughout document	Minor	Updated citation date for numerous documents
9/25/08	A.7.1	Minor	Corrected spelling - workplan
9/25/08	Table 14	Minor	Corrected spelling - chemical
9/25/08	Table 15	Minor	Corrected spelling - year
9/25/08	Table 16	Minor	Added Selenium to fish parameter table
9/25/08	B4.4	Minor	Corrected – to EFO should contact lab if results are not returned in correct time frame
9/25/08	A9.3	Minor	Corrected – to EFO should contact lab if results are not returned in correct time frame
9/25/08	Table 50	Minor	Deleted staff person that retired
9/25/08	D1	Minor	Corrected spelling – acquired
9/25/08	References	Minor	Deleted duplicate reference
9/25/08	A4.2.1.B	Minor	Corrected spelling – bacteriological
9/25/08	A5.2	Minor	Corrected Division of Water Pollution Control
9/25/08	B.1.4	Major	Change wording about Tiers
9/25/08	128	Minor	Delete page break
9/25/08	Table 41	Major	Change 10% to 20% on t duplicates
9/25/08	C1.2	Minor	Corrected WPC

9/25/08	A7.3.6	Minor	Corrected spelling – macroinvertebrate
1/28/09	A.5.2.6	Minor	Corrected number of staff positions.
1/29/09	References and document	Minor	Corrected title
1/29/09	A.9.8	Minor	Corrected years for data results to be kept at lab
2/9/09	Appendix B	Minor	Corrected spelling - Noncritical
2/9/09	Throughout	Major	Added periphyton to Ecoregion sampling
2/9/09	B5.3	Minor	Added reference title
2/11/09	Table 10	Minor	Corrected spacing in table
2/11/09	Page 97	Minor	Corrected spacing in document
2/11/09	D2.2.2	Minor	Reworded sentence
2/12/09	Appendix C	Minor	Added missing watershed numbers to 2 watersheds
2/13/09	Table 13	Minor	Updated position requirements
2/13/09	B10.7	Minor	Corrected spelling
2/27/09	A7.2 page 52	Minor	Rearranged sentences
3/5/09	Throughout	Minor	Corrected TDH lab staff names and positions
3/5/09	B4.1Table 35	Major	Corrected TDH lab methods
3/5/09	B4.2 Table 36	Major	Corrected DH lab methods and instrumentation
3/5/09	B.4.3 Table 37	Minor	Corrected TDH lab staff name and positions
3/5/09	Appendix D	Major	Corrected MDLs and Holding times
3/12/09	Throughout	Major	Added periphyton everywhere macroinvertebrate is mentioned
3/12/09	List of tables	Minor	Lined up table of contents
3/12/09	A52.1	Major	Corrected number of ecoregions

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3/12/09	Table 7	Minor	Corrected antidegradation terminology
3/12/09	A6.1	Minor	Corrected terminology
3/12/09	A6.1.1	Minor	Added info about periphyton and sampling
3/12/09	A6.1.4.	Major	Added field and lab equipment for periphyton sampling
3/12/09	Table 10	Minor	Corrected date QAPP due
3/26/09	Throughout	Minor	Corrected email addresses
4/3/09	Throughout	Minor	Corrected temperature
4/3/09	B3.1	Minor	Added info about custody seal
4/3/09	B1.10c	Major	Changed flow info for pathogen TMDL
4/8/09	Throughout	Minor	Corrected parameter conductivity to Specific conductance
4/8/09	B.1.5	Minor	Corrected time
4/8/09	Table 42	Minor	Corrected container for TOC

These revisions have been reviewed and approved. These revisions become effective on April 15 2009.

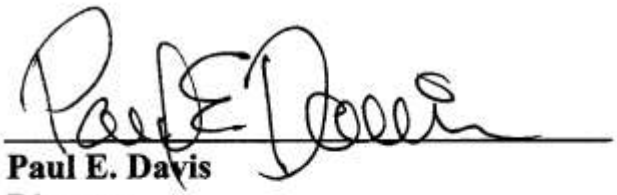
Paul E. Davis — 4/13/09
Paul E. Davis — **Date**
Director
TDEC Division of Water Pollution Control

Charles L. Head — 4/13/09
Charles L. Head — **Date**
Health and Safety/ Quality Assurance Director
Tennessee Department of Environment and Conservation

Revisions Jan 2010

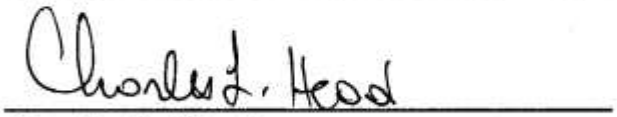
Date	Section/Page Draft Version 6	Revision Type	Revision Description
1/4/10	Throughout	Minor	Corrected TDEC and TDH staff and positions
1/4/10	Throughout	Major	Updated reference dates and titles
1/4/10	Throughout	Minor	Quarterly to monthly to send database to EFOS.
1/4/10	B.7	Minor	Calibration to minimally once a week
1/4/10	Appendix D	Minor	Changed container requirement for TOC and hardness
1/4/10	B.1.10c	Minor	For pathogen TMDL take flow – recommended as time allows
1/4/10	Appendix D	Minor	Changed MDL for Magnesium
1/4/10	Appendix D	Minor	Changed MDL for Mercury and added Jackson MDL for Mercury
1/4/10	Appendix D	Minor	Corrected temp for storing parameter on ice to $\leq 6^{o}$
1/12/10	Table 8	Minor	Added info about FECO parameters
1/12/10	Table 23	Minor	Updated fish sampling dates
1/13/10	B10.9	Minor	Program plan list reviewed quarterly
1/14/10	Table 42	Minor	Updated probe specifications
1/14/10	B10.5,6,7	Major	Updated info on changes in storing data and sending to EPA
1/14/10	Appendix D	Minor	Store bact samples at on ice $\leq 10^{o}$ C.
1/14/10	Table 44	Major	Added info about ICP-MS
1/14/10	Appendix C	Minor	Updated maps of sampling stations
1/22/10	Table 41	Minor	Added DO saturation info
1/22/10	B2.4	Minor	Added- also EFO Quality Team Member
1/28/10	A5.2.5	Minor	Added TDEC storage room
2/1/10	Appendix D	Major	Updated mdls

These revisions have been reviewed and approved. These revisions become effective on February 05, 2010.



Paul E. Davis
Director
TDEC Division of Water Pollution Control

2/4/10
Date



Charles L. Head
Health and Safety/Quality Assurance Director
Tennessee Department of Environment and Conservation

2/5/10
Date

TDEC QUALITY ASSURANCE PROJECT PLAN
FOR 106 MONITORING
EVALUATION INSTRUCTIONS

As this Quality Assurance Project Plan for 106 Monitoring is used, it will become apparent which changes or improvements are needed. Specific recommendations for improvements or changes are solicited as well as information concerning typographical or formatting errors. Please copy this page and complete all questions. Electronic versions of this are encouraged especially if comments are significant.

Your Name _____
Division _____
Address _____
E-mail Address _____
Telephone Number _____
Document Effective Date _____
Section(s) and Page Number(s) to which your comments apply _____
Comments _____

Send all comments, along with the following information, to the address below.

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A3 DISTRIBUTION LIST

Copies of this document were distributed to the following individuals in Tennessee Department of Environment and Conservation (TDEC) and Tennessee Department of Health (TDH) (Table 1). Additional copies were distributed to non-TDEC agencies and individuals upon request (including other state and federal agencies, consultants, universities, etc.). An updated list is maintained in the Planning and Standards Section (PAS). The system for document control is described in the *Environmental Programs Quality Management Plan*, Chapter 5 (TDEC, 2005).

Table 1: QAPP Distribution List

QAPP Recipient Name	Organization	Title	Telephone Number E-mail Mailing Address	Document Control Number
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Table 1: QAPP Distribution List (Continued)

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A4 PROJECT/TASK ORGANIZATION

A4.1 Project Purpose Based Upon Data Quality Objectives

The overall organizational structure of the project and accountability of participating parties are described in this section. This QAPP ensures reproducible and defensible water quality assessments for use in TMDL development, 305(b) Report, and 303(d) List, and provides representative reference data for criteria development and assessments.

A4.2 Roles and Responsibilities

The responsibility for water quality monitoring and assessment is shared among the Planning and Standards Section (PAS), Watershed Management Section (WMS), and Environmental Field Offices (EFO) personnel.

- PAS develop and update QAPP.
- Project QA manager (Deputy Director) approves the Quality Assurance Project Plan and ensures that it is followed by field staff and assessors.
- TDEC WPC and TDH field staff collect surface water quality monitoring data.
- Surface water samples are analyzed by TDH Environmental Laboratory staff, who then report results to Water Pollution Control (WPC) field staff and Planning and Standards (PAS) staff.
- Biological samples are analyzed by TDH and EFO staff, who then report results to PAS.
- PAS manager, WMS manager, and EFO staff jointly assess water quality results.

A4.2.1 Roles and Responsibilities.

Table 2 lists planning team members. Table 3 contains a summary of the roles and responsibilities of individuals and organizations participating in this project including principal data users, decision makers, trainers, purchasing staff, data management staff, records management staff, laboratory personnel, TDEC management, Quality Management Program staff and others. Organizational charts are included in Appendix B.

Table 2: List of Planning Team Members

Name	Organization	Person to Whom Reports	Telephone Number	E-Mail Address	Fax Number
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Ryan Owens	TDEC-WPC-CLEFO	Garland Wiggins	931-840-4170	Ryan.Owens@tn.gov	931-380-3397
Rob Howard	TDEC-WPC-CKEFO	Garland Wiggins	931-432-7632	Rob.Howard@tn.gov	931-432-6952
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Jeff Horton	TDEC-WPC-JCEFO	Garland Wiggins	423-854-5446	Jeff.Horton@tn.gov	423-854-5401
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Charles Head	TDEC/E	Paul Sloan	615-532-0998	Chuck.Head@tn.gov	615-532-8007

Table 3: Planning Team Members Roles and Responsibilities

Name	Project Role and Responsibility
Paul E. Davis	Division director
Garland Wiggins	• Purchase approval • QA Project Plan manager
Sherry Wang	• TMDL decisions and development • Watershed planning documents • Project planning • GIS management
Greg Denton	• Project planning • Water quality standards • Ecoregion reference management • SOP development and training coordination • Data QC • Data management • Record management • Data analyses and assessment decision • Report generation
Richard Urban	Water quality monitoring and assessment
Ryan Owens	Water quality monitoring and assessment
Rob Howard	Water quality monitoring and assessment
Pat Patrick	Water quality monitoring and assessment
Jeff Horton	Water quality monitoring and assessment
Paul Schmierbach	Water quality monitoring and assessment
Terry Templeton	Water quality monitoring and assessment
Joe E. Holland	Water quality monitoring and assessment
Bob Read	Laboratory analyses
Charles Head	Health and Safety/Quality Assurance Director

A4.2.1.A Management Responsibilities

The education, training, and experience for staff with management and supervisory responsibility in the project are described as follows.

1. **Director**
   (Includes: Environmental Program Director)

   Education and Experience: Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, or other acceptable field and five years of full-time professional environmental program work including at least one year managerial experience.

Responsibilities: This position functions as the director for a statewide environmental regulatory division. The Director is an executive service position that has additional qualifications as specified by the appointing authority.

2. Environmental Managers
(Includes Environmental Program Manager 1, 2, and 3, Environmental Field Office Manager, and Environmental Specialist 6)

Education and Experience: Graduation from an accredited college or university with a bachelor's degree in environmental science, biology, chemistry, geology, or other acceptable field and five years of full-time professional environmental program work including at least one year supervisory experience.

Responsibilities: These positions manage programs and environmental professional subordinates either in the Central Office or in Environmental Field Offices. The job responsibilities of these staff members are:

- Through subordinate supervisory and management personnel, assigns, trains, supervises, and evaluates technical staff.
- Managing environmental monitoring work.
- Participating in establishing standards, laws, rules, regulations, and administrative policies and procedures.
- Managing preparation and maintenance of records and reports.
- Reviewing report findings.

3. Laboratory Supervisor 3

Education and Experience: Possession of a doctorate in microbiology, biology, chemistry, or public health and laboratory practices from an accredited university and two years of responsible professional health laboratory experience and licensed as a Medical Laboratory Technologist by the Tennessee Department of Health. This Executive Service position has additional qualifications as specified by the appointing authority.

Responsibilities: This position manages all external and central environmental laboratory operations. The job responsibilities of this employee include:

- Managing internal, external, and other personal request for information, explaining laboratory results and related matters.
- Preparing, checking, and reviewing laboratory technical records and reports for accuracy and conformity.

A4.2.1.B Quality Assurance Responsibilities

See Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006), the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) for qualifications and responsibilities of quality assurance team.

The person responsible for maintaining the official, approved Quality Assurance Project Plan is Garland Wiggins, Deputy Director, TDEC, WPC.

A4.2.1.C Field Responsibilities

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006), the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provide qualifications and responsibilities of field personnel.

A4.2.1.D Laboratory Responsibilities

The TDH Environmental Laboratories will perform chemical and bacteriological analyses for this project. The education, training, and experience for lab staff are described below.

See the *Environmental Organic SOPs* (TDH, 2002-2009) and the *Environmental Inorganic SOPs* (TDH, 2002-2009) for qualifications and responsibilities for chemistry laboratory personnel. Microbiology laboratory personnel are licensed as a Medical Laboratory Technologist by the Tennessee Department of Health and perform standardized microbiological laboratory tests. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) provides qualifications and responsibilities for TDEC WPC and TDH Aquatic Biology (AB) personnel performing biological analyses.

A4.2.1.E Other Stakeholders (Table 4)

Table 4: Other Stakeholders

Agency	Physical Data	Biological Data	Chemical Data	Bact. Data
US Army Corp of Engineers		X	X	
US Environmental Protection Agency	X	X	X	X
US Office of Surface Mining	X		X	
Tennessee Valley Authority	X	X	X	X
US Geological Survey	X	X	X	X
Tennessee Wildlife Resources Agency	X	X		
Phase II MS4 permittees	X	X	X	X

Table 4: Other Stakeholders (Continued)

Agency	Physical Data	Biological Data	Chemical Data	Bact. Data
NPDES permittees	X	X	X	X
Universities	X	X	X	X

A4.2.2 Organizational Chart

Organizational charts for the project are included in Appendix B. The charts show relationships and lines of communication among all project participants.

A4.3 Key Resources

The primary data source is monitoring conducted by WPC personnel.

The TDH Environmental Laboratories analyzes chemical, bacteriological, and Semi-Quantitative Single Habitat (SQSH) biological samples. The primary data source, for reservoirs and large rivers are Tennessee Valley Authority (TVA) and United States Army Corp of Engineers (USACE).

A4.4 Data Types (Table 5)

Table 5: Data Sources

Acceptance Criteria	Intended Use
Computer Databases	
Assessment Database (ADB)	Determine a waterbody's current assessment status.
Water Quality Database (WQDB)	Determine if previous samples have been collected at a sampling location and analyses results.
Semi-Quantitative Database (SQDATA)	Database for SQSH biological data including taxa list and metric calculations.
STORET	Determine if data from other agencies have been collected at a given location since 1999.
On-line Water Quality Assessment Database	Used to determine ecoregion, and watershed boundaries and assessment status.
High Quality Waters Database	Used for determining antidegradation status.
Literature Files	
Final Version Year 2008 303(d) List (TDEC, 2008)	Lists impaired waterbodies by watershed. Use to determine needed 303(d) monitoring.
Rules of the TDEC Division of WPC, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007)	Use to determine appropriate water quality criteria.

Table 5: Data Sources (Continued)

Acceptance Criteria	Intended Use
Rules of the TDEC Division of WPC, Chapter 1200-4-4, Use Classifications for Surface Waters (TDEC-WQCB, 2007)	Use to identify assigned use designations.
WPC Monitoring and Assessment Program Plan (TDEC, 2009)	Used to plan monitoring schedule including parameters and site locations.
Development of Regionally-Based Interpretations of Tennessee's Narrative Nutrient Criterion (Denton et al, 2001)	Use as guidance for determining appropriate nutrient criteria.
QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2006)	Use as guidance for appropriate habitat scores. Use to score biorecon and SQSH results.
QSSOP for Chemical and Bacteriological Sampling of Surface Waters (TDEC, 2009)	Use as guidance for collecting chemical and bacteriological samples.
Historical Databases	
Legacy STORET	Determine if data from other agencies have been collected at a given location prior to 1999.
Paper Files	
Watershed Files	Used to store biorecon taxa lists and field observations.
Ecoregion Files	Used to store reference condition information.
Antidegradation Files	Used to store antidegradation reviews.

A5 PROBLEM DEFINITION AND BACKGROUND

A5.1 Problem Definition

The purpose of the division's water quality monitoring program is to provide a measure of Tennessee's progress toward meeting the goals established in the Federal Clean Water Act and the Tennessee Water Quality Control Act. This is achieved by determining use-attainment status of surface waters of the State.

To accomplish this task, data are collected and interpreted in order to:

1. Assess the condition of the state's waters.
2. Identify problem areas with parameter values that violate Tennessee numerical or narrative water quality standards.
3. Identify causes and sources of water quality problems.

4. Document areas with potential human health threats from fish tissue contamination or elevated bacteria levels.
5. Establish trends in water quality.
6. Gauge compliance with NPDES permit limits (Table 6).
7. Document baseline conditions prior to a potential impact or as a reference stream for downstream uses or other sites within the same ecoregion and/or watershed.
8. Assess water quality improvements based on site remediation, implementation of Best Management Practices, and other restoration strategies (Table 6).
9. Identify proper water-use classification, including antidegradation policy implementation.
10. Identify natural reference conditions on an ecoregion basis for refinement of water quality standards.

Table 6: Pollution Response Agencies

Problem	Agency	Solution
Point Source Pollution	WPC Permit and Enforcement Sections	Tighten permit limits and enforce permit violations
Non Point Source Pollution	Department of Agriculture	Grant assistance for voluntary cleanup and education
Waterbody Alteration	WPC Natural Resource Section	Aquatic Resources Alteration Permit (ARAP) and enforcement and implementation

To gauge Tennessee's progress toward meeting the goals of the *Federal Water Pollution Control Act* (U.S. Congress, 2000) and *Tennessee Water Quality Control Act* (TN Secretary of State, 1999), water quality data are compared to *Rules of the TDEC Division of WPC*, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WCQB, 2007) and the Level IV ecoregional reference data set (Table 7).

A5.2 Historical and Background Information

Tennessee first created a water pollution regulatory organization in 1927. In 1929, the Department's scope was expanded to include stream pollution studies to protect potential water supplies. A Stream Pollution Study Board charged with evaluating all available water quality data in Tennessee and locating the sources of pollution was appointed in 1943. The completed study was submitted to the General Assembly in 1945. Subsequently, the General Assembly enacted Chapter 128, Public Acts of 1945.

The 1945 law was in effect until the Water Quality Control Act of 1971 was passed. In 1972, the Federal Clean Water Act was passed. Tennessee revised the Water Quality

Control Act in 1977 and began a statewide stream monitoring program. In 1985, the Division of Water Quality Control was divided into the Division of Water Pollution Control and the Division of Water Supply. The Division of Water Pollution Control continues to monitor surface water for 305(b) and 303(d) assessments.

A5.2.1 Ecoregions

In 1995, the division began ecoregion delineation and reference stream monitoring. Tennessee has 31 Level IV ecological subregions in the state. Reference sites were selected to represent the best attainable conditions for all streams with similar characteristics. Reference conditions represent a set of expectations for physical habitat, general water quality and the health of the biological communities in the absence of human disturbance and pollution. Selection criteria for reference sites included minimal impairment and representativeness. Streams that did not flow across subregions were targeted to identify the distinctive characteristics of each subregion.

A5.2.2 Watersheds

In 1996, WPC adopted a watershed approach that reorganized existing programs based on management and focused on place-based water quality management. This approach addresses all Tennessee surface waters including streams, rivers, lakes, reservoirs and wetlands. There are 54 USGS eight-digit hydrologic units (HUC) in the state that have been divided into five monitoring groups for assessment purposes. One group, consisting of between 9 and 16 watersheds, is monitored and assessed each year. This allows intense monitoring of a limited number of watersheds each year, with all watersheds monitored every five years.

A5.2.3 Total Maximum Daily Load (TMDL) Monitoring

In 1998, the division entered into an agreement with USEPA "to establish numeric TMDLs or to develop pollution control requirements for the Water Quality Limited Streams identified on the 1998 303(d) List or then-current 303(d) List" (Tennessee Environmental Council et al, 2001). To comply with this agreement and the resulting TMDL development schedule, at least two 303(d) listed waterbody segments in the watershed group are intensively monitored using TMDL protocols by each EFO every fiscal year.

A5.2.4 Site Description

Monitoring sites are located throughout Tennessee's 54 watersheds. For specific information on planned sampling locations see the divisions program plan (TDEC, 2009). Maps of scheduled monitoring stations are found in Appendix C.

A5.2.5 Past Data Collection Activities

Water quality data have been collected throughout the state since the late 1920's. Various approaches have been used to collect water quality information including fish population surveys, fish tissue analyses, bioassay testing, macroinvertebrate surveys, chlorophyll analyses, periphyton surveys, diurnal dissolved oxygen monitoring, habitat assessments, geomorphological surveys, as well as chemical and bacteriological monitoring. Historical water quality data prior to 1999 are in Legacy STORET. All other data and reports are stored in the WPC library and TDEC storage room.

A5.2.6 Involved Parties, Resources

Water Pollution Control has approximately 234 positions, 188 are filled. Approximately 70 personnel are assigned in whole or part to monitoring and assessment activities (including both technical and support staff). Water quality monitoring is funded by state appropriation and EPA funds.

Table 7: Project Decision Statements and Actions

DECISION STATEMENT	ACTION TO BE TAKEN WITH REASON
Prioritize TMDL development and collect appropriate data.	Develop TMDL.
Identify natural reference conditions on an ecoregion basis for refinement of water quality standards. (Monitor Level IV ecoregional reference sites.)	Data used to refine Water Quality Criteria and ecoregional water quality expectations.
Monitor 303(d) listed waters	Refine 303(d) List.
Assess the condition of the state's waters.	Compare monitoring results to *Rules of TDEC Division of WPC*, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007) and regional reference data to determine if waters are supporting of designated uses. Publish biennial 305(b) reports.
Identify problem areas with parameter values that violate Tennessee numerical or narrative water quality standards. Identify causes and sources of water quality problems.	Include in the 303(d) List.
Document areas with potential human health threats from fish tissue contamination or elevated bacteria levels.	Notify public of water contact or fish consumption advisory at waterbodies that pose a threat to human health.
Identify waterbody-use classification.	Assign use classification to all monitored waterbodies in the watershed group. Identify antidegradation status for waters where regulatory decisions are needed.

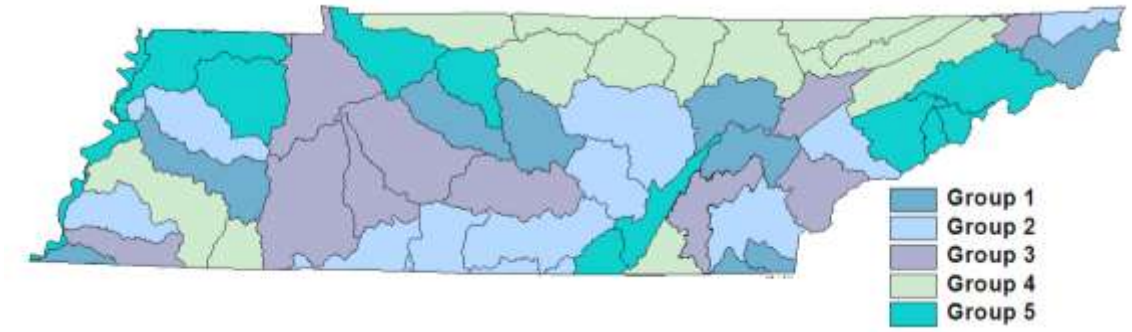
A6 PROJECT/TASK DESCRIPTION AND SCHEDULE

A6.1 Description of the Work Performed

The division maintains a statewide monitoring system of approximately 7000 stations. In addition, new stations are created every year to increase the number of assessed waterbodies. Approximately 400 stations were monitored in fiscal year 2009 (Appendix C).

Geographical information, station locations, and sampling objectives are included in the division's program plan (TDEC, 2009). Stations are sampled monthly, quarterly, or semi-annually, depending on the requirements of the project.

Monitoring is driven and prioritized by water quality program data requirements. Each year one of five watershed groups are monitored (Figure 1). Within each watershed cycle, monitoring locations across the state are determined by staff members in the eight Environmental Field Offices (EFOs) and the central office.



	Monitoring Years	West Tennessee	Middle Tennessee	East Tennessee
GROUP 1	1996 2001 2006 2011 2016	• Nonconnah • South Fork of the Forked Deer	• Stones • Harpeth	• Watts Bar • Ocoee • Emory • Watauga • Conasauga
GROUP 2	1997 2002 2007 2012 2017	• Loosahatchie • North Fork Forked Deer • Forked Deer	• Collins • Caney Fork • Wheeler Res. • Upper Elk • Lower Elk • Pickwick Res.	• Hiwassee • Fort Loudoun • South Fork Holston (Part)
GROUP 3	1998 2003 2008 2013 2018	• Wolf • TN Western Valley (Lower) • TN Western Valley (Upper)	• Upper Duck • Lower Duck • Buffalo	• Lower Tennessee (Part) • Little Tennessee • Lower Clinch • North Fork Holston • South Fork Holston (Part)

GROUP 4	1999 2004 2009 2014 2019	• Hatchie • Little Hatchie	• Red • Barren • Cumberland (Old Hickory Reservoir) • Upper Cumberland • Upper Cumberland (Cordell Hull) • Obey	• South Fork Cumberland • Upper Cumberland • Powell • Upper Clinch • Holston • Lower Tennessee • Clear Fork • Lower Tennessee (Part)
GROUP 5	2000 2005 2010 2015 2020	• Mississippi • Obion • South Fork Obion	• Barkley Res. • Cheatham Res. • Guntersville Res.	• Sequatchie • Upper French Broad • Lower French Broad • Pigeon • Nolichucky

Figure 1: Watershed Groups

After determining the watersheds to be monitored in a given year, monitoring resources are prioritized as follows:

1. **Antidegradation Monitoring:** The primary objective for antidegradation monitoring is to assess the condition of the state's waters in regards to permits. Waterbodies are evaluated as needed, generally in response to requests for new or expanded National Pollution Discharge Elimination Systems (NPDES) or general or individual Aquatic Resource Alteration Permit (ARAP). Waterbodies are evaluated for antidegradation status using a standardized process. Since permit requests usually cannot be anticipated, these evaluations are generally not included in the division's program plan (TDEC, 2009). The number of antidegradation evaluations conducted by the state is steadily increasing as the process becomes more refined and standardized. A separate QAPP will address antidegradation evaluations.

2. **Monitoring for TMDL Development:** The primary objective for TMDL monitoring is to identify remaining sources of pollution and allocate pollution control needs in places where water quality goals are still not being achieved. For each Environmental Field Office, the next priority is given to waterbody monitoring required to develop TMDLs. Monitoring for a minimum of two TMDLs in the watershed group is scheduled in each of the eight EFOs. The number of waterbodies, stations, sample frequency and parameters are coordinated with the WMS manager to meet objectives for each TMDL. TMDL monitoring is generally performed monthly for one or two years.

3. **Ecoregion Reference Monitoring:** The primary objective of ecoregion reference monitoring is to identify natural reference conditions on an ecoregion basis for

refinement of water quality standards. Established reference stations are monitored in conjunction with the watershed cycle. Ecoregion reference sites located in the fiscal year watershed group are monitored. Each station is sampled quarterly for chemistry and pathogens as well as in the spring and fall for macroinvertebrates. Both Semi-Quantitative Single Habitat and biorecon samples are collected in the spring and fall to provide data to meet biocriteria and biorecon guidelines. Periphyton sampling will be collected annually. If watershed screening results indicate a potential new reference site, more intensive reference stream monitoring protocols are used at that station to determine potential inclusion in the reference database.

4. **303(d) Listed Segments Monitoring:** The primary objective of 303(d) listed segments monitoring is to identify problem areas with parameter values that violate Tennessee numerical or narrative water quality standards. During each watershed cycle, at least one station in every waterbody segment included on the 303(d) List within the targeted watersheds are monitored. Minimally, these stations are sampled for the pollutants for which they are listed and a macroinvertebrate biological sample is collected, unless the water is listed only for pathogens. No macroinvertebrate sample is needed if the only impairment is pathogen contamination. If a segment is included in the 303(d) List because it does not meet the fish and aquatic life designated use and no change of water status is suspected, either a biorecon or a Semi-Quantitative Single Habitat (SQSH) macroinvertebrate sample is collected. However, if a biorecon is collected and it scores ambiguous or good, a SQSH must be collected to confirm improvement in water quality.

   If a different impairment (other than pathogens) is listed, either a biorecon or SQSH sample is collected. *E. coli* samples are collected if the segment does not meet recreation uses, unless the recreational use impairment is caused by fish tissue or sediment contamination.

   If water quality improves and the waterbody becomes a candidate for removal from the 303(d) List due to support of water quality criteria, a Semi-Quantitative Single Habitat macroinvertebrate sample is collected and analyzed, unless SQSH was previously collected. If the SQSH sample meets biocriteria, additional chemical monitoring may be required. The number of samples, parameters, and data needed, varies by pollutant. Section B describes monitoring for potential 303(d) delisting.

5. **Long Term Trend Station Monitoring:** The primary objective for long term trend station monitoring is to establish trends in water quality. For water quality trend analyses, established sites are monitored. Chemical samples are collected and field parameters are measured at least quarterly at each of these stations.

6. **Watershed Monitoring**: Once the previous priorities are met, each EFO monitors as many additional stations as possible to increase the percentage of assessed waterbodies. Minimally, macroinvertebrate biorecons, habitat assessments, and field measurements of DO, Specific conductance, pH and temperature are conducted at these sites. Chemical samples are collected as needed to determine potential pollutant sources. Bacteriological samples are collected to determine recreation use-support. SQSH samples are collected if biorecons score in the ambiguous category, unless other information such as chemical, habitat or field observations clarify assessments. Emphasis is placed on waterbody segments that have not previously been assessed.

In addition to monitoring conducted by EFO staff in conjunction with the watershed cycle, other types of monitoring include:

1. **NPDES Monitoring**: Tennessee requires permitted dischargers to conduct upstream and downstream macroinvertebrate biological and habitat monitoring following the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) in many of its NPDES permits. These data are submitted to the state for evaluation. In this way, Tennessee supplements its monitoring program using permitted dischargers to provide information about receiving waters.

2. **Fish Consumption Advisory**: The primary objective for fish tissue monitoring is to document areas with potential human health threats from fish tissue contamination. Fish tissue monitoring for fish advisories is planned by a workgroup consisting of staff from TDEC-WPC, TVA, Oak Ridge National Laboratory (ORNL) and Tennessee Wildlife Resources Agency (TWRA). The workgroup meets annually to coordinate a monitoring strategy. Monitoring is conducted once a year and rotated among the stations.

3. **Probabilistic Monitoring**: Probabilistic monitoring utilizes random station selection. Probabilistic monitoring studies are generally special projects.

4. **Special Studies:** When grants become available, Tennessee proactively conducts special studies to enhance its water quality monitoring program. In the past, these studies have included ecoregion delineation and reference stream selection, nutrient criteria development, and diurnal dissolved oxygen studies. The state has recently conducted a probablistic wadeable streams assessment and a stream characterization study that is a follow-up to the original dissolved oxygen project. The latter will provide additional information on diurnal dissolved oxygen patterns as well as initiate nutrient criteria development for nonwadeable streams and rivers that cross ecoregions in west Tennessee. This project is funded by 104(b)(3) grant money.

5. **Reservoir Monitoring:** TDEC relies on TVA and USACE for most of the large reservoirs (over 1000 acres) monitoring. Upon receipt of additional federal funding, WPC intends to increase smaller reservoir monitoring to support nutrient and biological criteria development. The state recently participated in a national probabilistic study.

6. **Fish Tissue Monitoring:** The primary objective for fish tissue monitoring is to document areas with potential human health threats from fish tissue contamination. Fish tissue monitoring is planned by a workgroup consisting of staff from TDEC (WPC and DOE-Oversight), TVA (Tennessee Valley Authority), TWRA (Tennessee Wildlife Resources Agency, and ORNL (Oak Ridge National Laboratory). The workgroup meets annually to discuss fish tissue monitoring needs for the following fiscal year. Data from these surveys help the division assess water quality and determine the issuance of fishing advisories.

7. **Wetlands Monitoring:** TDEC does not currently have resources available for comprehensive wetland monitoring. Protection and restoration of wetlands is considered a higher priority. Tennessee was one of the first states in the nation to develop a wetland protection strategy and has been recognized by EPA for establishing a national model for wetlands planning. WPC does have an assessment method for making antidegradation determinations or more precisely to determine if the wetland is exceptional Tennessee waters.

8. **Evaluation of Stream Mitigation:** WPC performs evaluations of Aquatic Resources Alteration Permit (ARAP) stream mitigation projects and the success and compliance of mitigation required by order of the Water Quality Control Board.

9. **Threatened and Endangered Species:** WPC identifies threatened and endangered species and participates in restoration projects as resources allow.

A6.1.1 Measurements Expected During Project

Table 8 provides the parameters list for each type of site sampling. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) describes protocols for collection of benthic macroinvertebrate samples and habitat assessment. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) describes chemical and bacteriological sampling, field parameter readings, and flow measurement procedures.

1. **TMDL Measurements:** *Monitoring to Support TMDL Development* (TDEC, 2001) specifies needed monitoring for TMDL development. Flow, field parameters (DO, pH, Specific conductance, and temperature), and specific chemical and/or bacteriological samples are collected monthly during periods of concern.

2. **Ecoregion Reference Monitoring**: Ecoregion reference sites located in the watershed monitoring group are monitored on the watershed cycle. Biorecons and Semi-Quantitative Single Habitat samples are collected at ecoregion reference sites in the spring and fall. Chemical and bacteriological samples and flow and field parameter readings are taken quarterly. Periphyton samples are to be taken annually during the growing season.

3. **303(d) Listed Waterbody Monitoring**: Minimally, all 303(d) listed waterbodies in the watershed group are monitored for the listed cause(s) and a biorecon (or SQSH) sample is collected, unless the water is listed only for pathogens. No macroinvertebrate sample is needed if the only impairment is pathogen contamination. If water quality improves and a waterbody becomes a candidate for removal from the 303(d) List a SQSH sample is collected instead of a biorecon sample.

4. **Long Term Trend Station Monitoring:** Minimally chemical parameters listed in Table 8 are collected quarterly at long term trend stations.

5. **Watershed Sites Monitoring**: Minimally, a biological sample (biorecon or SQSH), habitat assessment, and field parameters (DO, temp, pH, Specific conductance) are collected to determine if the waterbody fully supports fish and aquatic life. If a biorecon is collected and it scores in the ambiguous category, a Semi-Quantitative Single Habitat (SQSH) sample is collected, unless other data clarifies assessment. To assess recreational uses, monthly bacteriological samples are collected.

Table 8: Parameters for Surface Water Sampling

Parameter	**TMDLs**				**Reference Sites Ecosites* and FECO** Sites**	**303(d)†**	**Long Term Trend Stations**	**Watershed Sites**
	Metals† /(pH)	DO	Nutrients	Pathogens				
Acidity, Total	X (pH)							
Alkalinity, Total	X (pH)				X	O	X	O
Aluminum, Al						O	X	O
Ammonia Nitrogen as N		X	X		X	O	X	O
Arsenic, As					X	O	X	O
Cadmium, Cd	X†				X	O	X	O
Chromium, Cr	X†				X	O	X	O
$CBOD_5$		X				O	X	O
Color, Apparent					X		X	
Color, True					X		X	
Specific conductance (field)	X	X	X	X	X	X	X	X
Copper, Cu	X†				X	O	X	O
Cyanide, Cy							X	
Dissolved Oxygen (field)	X	X	X	X	X	X	X	X
Diurnal DO		X	X					
E. Coli				X	X	O	X	O
Fecal Coliform				X	X	O	X	O
Enterococcus					X			
Flow	X	X	X	X depends	X	O	X	O
Iron, Fe					X	O	X	O
Lead, Pb	X†				X	O	X	O
Manganese, Mn					X	O	X	O
Mercury, Hg						O	X	O
Nickel, Ni	X†					O	X	O
Nitrate + Nitrite		X	X		X	O	X	O
pH (field)	X	X	X	X	X	X	X	X
Residue, Dissolved					X	O	X	O
Residue, Settleable						O	X	O
Residue, Suspended	X		X	X	X	O	X	O
Residue, Total						O	X	O
Selenium, Se	X				X	O	X	O
Sulfates					X (69d & 68a)	O	X	O
Temperature (field)	X	X	X	X	X	X	X	X
Total Hardness	X				X	O	X	O
Total Kjeldahl Nitrogen		X	X		X	O	X	O
Total Organic Carbon	X		X		X	O	X	O
Total Phosphorus		X	X		X	O	X	O
Turbidity			X	X	X	O	X	O
Zinc, Zn	X†				X	O	X	O
Biorecon					X	X		X
SQSH					X	O (replace biorecon)		O (replace biorecon)
Habitat Assessment					X	X		X
Periphyton			X		X			

*These analyses are required for Ecosites.

**For FECO sites follow the FECO project plan for sampling parameters until 2013 then follow the Ecoregion sampling plan for parameters.
†Pollutant on 303(d) List.
Optional (O) - Not collected unless the waterbody has been previously assessed as impacted by that substance or if there are known or probable sources of the substance.

A6.1.2 Special Personnel, Credentials and Training Requirements

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) defines qualifications for personnel collecting macroinvertebrate biorecon or Semi-Quantitative Single Habitat samples. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) describes qualifications for personnel collecting chemical or bacteriological samples, flow and field parameters. The draft *QSSOP for Periphyton Stream Surveys* (TDEC, 2009) describes qualifications for personnel collecting periphyton samples.

Management personnel involved in the assessment of waterbodies must meet the criteria in section A4.2.1 and have at least one-year experience in water quality assessment. The PAS personnel must have expertise in the Assessment Database (ADB). Personnel involved in geo-indexing of water quality information have training in the use of Environmental Systems Research Institute (ESRI), ArcView software and the ADB. Table 9 lists roles of key personnel.

A6.1.3 Regulatory Citation

Under the authority of *The Tennessee Water Quality Control Act of 1977* (Tennessee Secretary of State, 1999), 106 monitoring is conducted by TDEC Division of Water Pollution Control. Use designations are defined in *Rules of TDEC Division of Water Pollution Control*, Chapter 1200-4-4, Use Classifications for Surface Waters (TDEC-WQCB, 2007). Specific criteria are described in *Rules of TDEC Division of Water Pollution Control*, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007). Required criteria for each parameter is in Table 13.

A6.1.4 Special Equipment Requirements

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) lists equipment and supplies needed for collection of macroinvertebrate biorecon or Semi-Quantitative Single Habitat samples. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) lists the equipment needed to collect chemical or bacteriological samples. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) lists the equipment needed to collect periphyton samples. The equipment list is below. The water quality assessment team uses laptop computers with ADB and ArcView software in the water quality assessment process.

Chemical and Bacteriological General Field Equipment

Waders

External sample tags

Sample request forms

Field Flow Sheet or field book

Topographic maps (USGS quadrangle maps) may also be referred to as topos or quads

Tennessee Atlas and Gazetteer

GPS unit for recording latitude and longitude in decimal degrees at new stations

Cell Phone or other communication device (recommended)

Calibrated dissolved oxygen meter

Calibrated pH meter

Calibrated conductivity meter

Calibrated temperature meter or thermometer in ^{o}C

Repair kit for water parameter meters (DO replacement membrane for multi-day trips)

Calibrated flow meter, wading rod (10^{th} of feet markings), and sensor cable

Measuring or surveyors tape (10^{th} of feet markings) and rope long enough to span the river or stream

Stakes, clamps, and hammer

Flow meter manual and screwdriver

Spare batteries for all meters

Waterproof pens (Sharpies®), pencils and black ballpoint ink pens (not roller-ball)

Flashlights in case detained after dark

Duct tape for emergency repairs

First aid kit

Watch

Map wheel (for calculating stream miles if determining stations in the field)

Sample bottles + 10% QC bottles

1 gallon plastic zip-type bags (recommended)

Powder-free latex or nitrile gloves (Required for nutrient sampling)

Shoulder length powder-free gloves (if collecting trace metals or mercury)

Ice stored in coolers (ice may be placed in plastic bags for easier handling)

Clean coolers

Temperature blank bottle (1/cooler)

Custody seals

Camera for documenting potential pollution sources and waterbody conditions

Additional Items Needed for Non-Wadeable Sites

Bacteriological sampling: swing sampler or other appropriate bottle holder or sterile sampling device

Inorganic chemical sampling: Teflon® or High Density Polyethylene (Nalgene®) bucket attached to a rope, Teflon® Kemmerer, bailer, or peristaltic pump

Organic chemical sampling: stainless steel bucket (attached to a rope), Kemmerer, or bailer

If Using a Boat

Boat with appropriate safety equipment, paddles, and PFDs

Additional Items Needed for Field Cleaning Equipment

Phosphate-free laboratory-grade detergent

Tap water stored in a clean covered tank, or squeeze bottle

Deionized water stored in a clean covered tank or squeeze bottle

Additional Items Needed for Diurnal Monitoring

Continuous monitoring probe

Sensor cable

Laptop computer programmed for the continuous monitoring multi-probe

Field manual for the probe and software

Stainless steel cable or chain

Crimps

Crimp and wire cutter pliers

Nylon cable

Appropriate anchoring and/or flotation device such as:

Rebar and hammer (firm substrate)

Wooden board (soft sand/silt substrate)

Concrete block (soft sand/silt substrate)

Float with probe holder to suspend the probe in the water column and a weight to hold it in place (deeper waters)

Additional Items Needed for Automatic Sampling

Automatic sampler

New Silastic® or equal tubing

New Teflon® or Tygron® or equal tubing

Clamps and/or electrical ties

Spare batteries

Ice

Macroinvertebrate Field Equipment

Waders

Forceps

Ethanol

External sample tags

Internal sample tags

Habitat Assessment Sheet (High gradient for riffles, Low gradient for glide-pool)

Biorecon Sheet (Biorecons only)

Biological Analysis Request Sheet (for Chain of Custody and/or samples sent to lab)

Topographic maps (USGS quadrangle maps) may also be referred to as topos or quads.

Tennessee Atlas and Gazetteer

½ gallon wide mouth plastic sample bottles for Semi-Quantitative samples

Small wide mouth plastic bottles for biorecons

Calibrated GPS unit

Calibrated Dissolved Oxygen meter and replacement membrane kit

Calibrated pH meter

Calibrated conductivity meter

Calibrated temperature meter or thermometer in ^{o}C

Spare batteries for all meters

Camera (preferably digital) with memory cards, floppy discs or film

Triangular dip net with 500-micron mesh (Biorecons and SQBANK samples only)

One meter square kick net with 500 micron mesh (SQKICK samples only)

Rectangular net (18”) with 500 micron mesh (SQKICK in streams less than 1 meter wide only)

White enamel or plastic pans for sorting debris (biorecons only)

Magnifying lens

Waterproof marking pens (Sharpies), pencils and black ballpoint ink pens (not roller-ball)

Flashlights

Duct Tape

First Aid Kit

Watch

Spherical densiometer (for canopy measurements)

Map Wheel (for calculating stream miles)

Periphyton Field Equipment

Waders

Forceps

External sample tags

Internal sample tags

Periphyton Data Sheet

Habitat Assessment Sheet (High gradient for riffles, Low gradient for glide-pool)

Stream Survey Sheet

Biological Analysis Request Sheet (for Chain of Custody and/or samples sent to lab)

Topographic maps (USGS quadrangle maps) may also be referred to as topos or quads.

Tennessee Atlas and Gazetteer

Calibrated GPS unit

Calibrated Dissolved Oxygen meter and replacement membrane kit

Calibrated pH meter

Calibrated conductivity meter

Calibrated temperature meter or thermometer in ^{o}C

Spare batteries for all meters and for camera

Camera (preferably digital) with memory cards or film for documentation of potential pollution sources and waterbody conditions

Magnifying lens

Waterproof marking pens (Sharpies), pencils and black ballpoint ink pens (not roller-ball)

Flashlights

Duct Tape

First Aid Kit

Watch

Spherical densiometer (for canopy measurements)

Map Wheel (for calculating stream miles) if station ID is to be assigned in the field

Disposable pipettes

Preservative (buffered formalin)

500 mL wide mouth sample jar (approx. 9-cm inner diameter), marked at the 100 mL fill point

Scissors or knife

125 mL amber wide-mouth sample bottle to hold final sample

Rapid Periphyton Survey Board

Periphyton Laboratory Equipment

The following equipment is needed to perform sample analysis.

Tissue homogenizer or blender

Calibrated (known volume) counting chamber such as a Nannoplankton chamber or a Palmer-Maloney Counting Cell or other

Pipettes

Compound microscope

Beaker

Naphrax or other high refractive index medium

Microscope slides

Slide coverslips

Bench Sheet

Slide Storage Box

Sodium bicarbonate

37% formaldehyde (formalin)

pH meter

Small containers

Balance

Nitric or sulfuric acid

Fume hood

Distilled water

A6.1.5 Project Assessment Techniques

The Tennessee WPC Monitoring and Assessment Program Plan (TDEC, 2009) describes project assessment techniques.

A6.1.6 Required Project and Quality Records (including types of reports needed)

Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006), of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) and of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describes project and quality control record handling protocols. After data are compiled, they are used to produce the following paper and electronic records:

Records:

- Water Quality Database (WQDB)
- Assessment Database (ADB)
- Semi-Quantitative Database (SQDATA)
- Laboratory report files
- Watershed files
- Ecoregion files
- Waterlog – Exceptional Tennessee Waters

Reports:

- *Final Version Year 2008 303(d) List* (TDEC, 2008)
- *2008 305(b) Report, The Status of Water Quality in Tennessee* (Denton et al, 2008)
- *WPC Monitoring and Assessment Program Plan* (TDEC, 2009)
- *Rules of the TDEC Division of WPC*, Chapter 1200-4-4, General Water Quality Criteria (TDEC-WCQB, 2007)
- *Rules of the TDEC Division of WPC*, Chapter 1200-4-4, Use Classifications of Surface Waters (TDEC-WCQB, 2007)

Table 9: Primary Roles of Key Personnel*

Name	Job Title	Station	Role
P. Davis	Director	CO	Project Management
G. Wiggins	Deputy Director	CO	QAPP Project Management
C. Head	Environmental Program Manager 3	CO	Quality Assurance Manager
G. Denton	Environmental Program Manager 1	CO PAS	Project Management
S. Wang	Environmental Program Manager 1	CO WMS	Project Management
D. Arnwine	Environmental Specialist 5	CO PAS	QA Project Management Data Analyses
L. Cartwright	Biologist 3	CO PAS	QA Project Management Data Analyses
M. Graf	Environmental Specialist 3	CO PAS	QA Data Analyses
R. Cochran	Environmental Specialist 5	CO WMS	TMDL Development Geo-indexing
D. Duhl	Environmental Specialist 5	CO WMS	Watershed Management
R. McGahen	Environmental Specialist 4	CO WMS	Watershed Management
K. McInnes	Environmental Specialist 3	CO WMS	Watershed Management
B. Evans	Environmental Protection Specialist 5	CO WMS	TMDL Development
D. Borders	Environmental Protection Specialist 4	CO WMS	TMDL Development
V. Steed	Environmental Protection Specialist 4	CO WMS	TMDL Development
B. Lewis	Environmental Protection Specialist 3	JEFO	Field Sampler
R. Howard	Environmental Field Office Manager	CKEFO	Management
J. Holland	Environmental Field Office Manager	NEFO	Management
N. Harris	Environmental Field Office Manager	KEFO	Management
J. Horton	Environmental Field Office Manager	JCEFO	Management
D. Owens	Environmental Program Manager 1	KSM	Management
P. Patrick	Environmental Field Office Manager	JEFO	Management
P. Schmierbach	Environmental Program Manager 2	KEFO	Management
T. Templeton	Environmental Field Office Manager	MEFO	Management

Table 9: Primary Roles of Key Personnel (Continued)

Name	Job Title	Station	Role
D. Urban	Environmental Field Office Manager	CHEFO	Management
R. Owens	Acting Environmental Field Office Manager	CLEFO	Management
L. Hoffman	Environmental Specialist 6	MEFO	Field Sampler/ Management
B. Matthews	Environmental Specialist 6	JEFO	Field Sampler/ Management
A. Rochelle	Environmental Specialist 6	NEFO	Field Sampler/ Management
T. Robinson	Environmental Specialist 6	JCEFO	Field Sampler/ Biological Analyses/Management
J. Burr	Environmental Specialist 5	KEFO	Field Sampler/ Biological Analyses
B. Hall	Environmental Specialist 5	CKEFO	Field Sampler
A. Fritz	Environmental Specialist 5	JEFO	Field Sampler/ Biological Analyses
J. Smith	Environmental Specialist 5	NEFO	Field Sampler/ Biological Analyses
D. Turner	Environmental Specialist 5	KSM	Management Field Sampler/ Biological Analyses
J. Innes	Environmental Specialist 5	CHEFO	Field Sampler/ Biological Analyses
A. Morbitt	Environmental Specialist 5	NEFO	Field Sampler
J. Brazile	Environmental Specialist 5	MEFO	Field Sampler/ Biological Analyses
M. Atchley	Environmental Specialist 4	KEFO	Field Sampler
B. Duffle	Environmental Specialist 4	NEFO	Field Sampler
B. Loudermilk	Environmental Specialist 4	NEFO	Field Sampler
M. Finks	Environmental Specialist 4	NEFO	Field Sampler
K. Sparks	Environmental Specialist 4	NEFO	Field Sampler /Biological Analyses
A. Young	Environmental Specialist 4	CHEFO	Field Sampler
R. Tipton	Environmental Specialist 4	JCEFO	Field Sampler
C. Doyle	Environmental Specialist 4	JCEFO	Field Sampler
L. Barrios	Environmental Specialist 3	MEFO	Field Sampler
J. Lyles	Environmental Specialist 3	NEFO	Field Sampler
R. Cooper	Environmental Specialist 3	JCEFO	Field Sampler/ Biological Analyses
J. Dees	Environmental Specialist 3	NEFO	Field Sampler
J. Dougan	Environmental Specialist 3	JEFO	Field Sampler
G. Horne	Environmental Specialist 3	CLEFO	Field Sampler

Table 9: Primary Roles of Key Personnel (Continued)

Name	Job Title	Station	Role
D. Hale	Environmental Specialist 3	JCEFO	Field Sampler/ Biological Analyses
S. Howell	Environmental Specialist 3	CHEFO	Field Sampler
S. Kington	Environmental Specialist 3	JEFO-SM	Field Sampler/ Biological Analyses
S. Turaski	Environmental Specialist 3	KSM	Field Sampler
B. Scott	Environmental Specialist 3	KEFO	Field Sampler
V. Mc Fall	Environmental Specialist 3	KEFO	Field Sampler
B. Wallace	Environmental Specialist 3	JEFO	Field Sampler
S. Hardy	Environmental Specialist 3	MEFO	Field Sampler
N. Paulson	Environmental Specialist 1/3	MEFO	Field Sampler
J. Mann	Environmental Specialist 3	KEFO	Field Sampler
C. Augustin	Biologist 4	CLEFO	Field Sampler/ Biological Analyses
M. Barb	Biologist 4	CHEFO	Field Sampler /Biological Analyses
B. Brown	Biologist 4	JCEFO	Field Sampler/ Biological Analyses
D. Murray	Biologist 4	KSM	Field Sampler/ Biological Analyses
G. Overstreet	Biologist 4	JEFO	Field Sampler/ Biological Analyses
K. Chance	Biologist 4	CKEFO	Field Sampler/ Biological Analyses
A. Goodhue	Biologist 3	NEFO	Field Sampler/ Biological Analyses
D. Sparks	Biologist 3	CHEFO	Field Sampler/ Biological Analyses
B. Smith	Biologist 3	JEFO	Field Sampler/ Biological Analyses
L. Everett	Biologist 3	KEFO	Field Sampler/ Biological Analyses
E. Vincent	Biologist 3	JEFO	Field Sampler/ Biological Analyses
L. Bonds	Chemist 3	KEFO	Field Sampler
B. Read	Lab Supervisor 3	TDH NLAB	Management, QA
O. Walker	Lab Supervisor 2 (Certified)	TDH JLAB	Management, QA

Table 9: Primary Roles of Key Personnel (Continued)

Name	Job Title	Station	Role
P. Singh	Lab Supervisor 1	TDH NLAB	Management, QA
D. Stucki	Biologist 3	TDH NLAB	Biological Analyses, Field Sampler, QA
S. Bonney	Biologist 3	TDH NLAB	Biological Analyses, Field Sampler
P. Alicea	Biologist 4	TDH NLAB	Biological Analyses, Field Sampler
C. Perry	Biologist 3	TDH NLAB	Biological Analyses, Field Sampler
T. McCollum	Biologist 3	TDH NLAB	Biological Analyses, Field Sampler
K. Gaddes	Biologist 3	TDH NLAB	Biological Analyses, Field Sampler
G. Harris	Biologist 3	TDH NLAB	Biological Analyses, Field Sampler
C. Ayers	Chemist 4	TDH NLAB	Management, Analyses, QA
C. Edwards	Chemist 4	TDH NLAB	Management, Analyses, QA
R. Mitchell	Chemist 4	TDH JLAB	Analyses, QA
E. McCrary	Chemist 4	TDH KLAB	Analyses, QA
S. Ufegbu	Chemist 2	TDH NLAB	Analyses
A. Wilson	Chemist 3	TDH NLAB	Analyses
S. Staller	Chemist 3	TDH KLAB	Analyses
A. Jeffries	Chemist 2	TDH JLAB	Analyses
D. Pillow	Chemist 2	TDH JLAB	Analyses
J. Liu	Chemist 2	TDH KLAB	Analyses
J. Grosenbeck	Chemist 2	TDH KLAB	Analyses
L. Satterwhite	Chemist 2	TDH NLAB	Analyses
D. Maldas	Chemist 3	TDH NLAB	Analyses

Table 9: Primary Roles of Key Personnel (Continued)

Name	Job Title	Station	Role
L. Maderal	Chemist 3	TDH NLAB	Analyses
P. Wilson	Chemist 2	TDH NLAB	Analyses
G. Guirguis	Chemist 2	TDH NLAB	Analyses
M. Chen	Chemist 2	TDH NLAB	Analyses
S. Burchfield	Chemist 3	TDH NLAB	Analyses
A. Bass	Chemist 2	TDH NLAB	Analyses
M. Pattanayek	Chemist 2	TDH NLAB	Analyses
P. Leathers	Chemist2	TDH NLAB	Analyses
A. Peeples	Chemist 2	TDH NLAB	Analyses
D. Turner	Chemist 2	TDH NLAB	Analyses
H. Hardin	Microbiologist 4 (Certified)	TDH NLAB	Analyses
R. Pegues	Microbiologist 4 (Certified)	TDH JLAB	Analyses
B. Frei	Microbiologist 4 (Certified)	TDH KLAB	Analyses
P. Arjmandi	Microbiologist 3 (Certified)	TDH NLAB	Analyses
K. English	Microbiologist 2 (Certified)	TDH NLAB	Analyses
B. Price	Microbiologist 3 (Certified)	TDH KLAB	Analyses
D. Sharp	Microbiologist 3 (Certified)	TDH JLAB	Analyses

*All personnel will be asked to do additional tasks as needed.

A6.2 Project Timeline for Monitoring, Analyses, and Reports

Table 10 provides project monitoring timelines and deliverable due dates for chemical, bacteriological, and biological analyses results. Table 11 provides project data reduction and report generation timelines.

A6.3 Project Budget

Water quality monitoring is funded by state appropriation and EPA grant dollars. Approximately $6.4 million, ($1.2 million federal), was obligated for employee salaries and benefits in support this program in state FY 2008-2009. Laboratory expenses for 2008-2009 were $1.5 million. Another $1.6 million is required for travel, printing, utility, communication, maintenance, professional service, rent, insurance, vehicle and equipment expenses.

Table 10: Project Monitoring Schedule

Activity	Collection		Assessment Period	Sample Delivery	Reporting Date
Watershed Monitoring	**Start Date**	**End Date†**			
Group 1	July 2001 July 2006 July 2011	June 2002 June 2007 June 2012	Oct. ’02-Feb. ‘03 Oct. ‘07-Feb. ‘08 Oct. ‘12-Feb. ‘13	*Chemical and bacteriological samples are delivered to TDH Environmental Laboratories within holding time* (Appendix D) **Macroinverte-brate SQSH samples are delivered to TDH Environmental Laboratories within 30 days of sampling (negotiated as needed).**	*Chemical and bacteriological data are due to PAS and the sampler in 25 days (negotiated if needed) **SQSH biological results are due December in year of ending date (negotiated if needed). **Biorecon data due as soon as processed and appropriate QC has been completed.
Group 2	July 2002 July 2007 July 2012	June 2003 June 2008 June 2013	Oct. ‘03-Feb. ‘04 Oct. ‘08-Feb. ‘09 Oct. ‘13-Feb. ‘14		
Group 3	July 2003 July 2008 July 2013	June 2004 June 2009 June 2014	Oct. ‘04-Feb. ‘05 Oct. ‘09-Feb. ‘10 Oct. ‘14-Feb. ‘15		
Group 4	July 2004 July 2009 July 2014	June 2005 June 2010 June 2015	Oct. ‘05-Feb. ‘06 Oct. ‘10-Feb. ‘11 Oct. ‘15-Feb. ‘16		
Group 5	July 2005 July 2010 July 2015	June 2006 June 2011 June 2016	Oct. ‘06-Feb. ‘07 Oct. ‘11-Feb. ‘12 Oct. ‘16-Feb. ‘17		

**QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2009) has additional information.
***QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) has specific information.
†The following fiscal year may be used to clarify ambiguous results or fill in data gaps.

Table 11: Project Data Reduction and Report Generation Schedule

Report Name	Report Recipient	Report Due Date
Biennial 305(b) Report	USEPA	April of even number years
Biennial 303(d) List	USEPA	April of even number years
303(d) Comment Responses	USEPA	One month after comment deadline.
WPC Monitoring and Assessment Program Plan	USEPA	July 1 each year
Water Quality Standards	USEPA WQCB TN Secretary of State	Minimally every 3 years
TMDL	USEPA	Per civil action (Tennessee Environmental Council et al, 2001)
106 Electronic Workplan	USEPA	August 1 each year
Mid-year Review	USEPA	July
End-of-Year Review	USEPA	January
Quarterly Activity Reports	USEPA WQCB Bureau of Environment	End of each quarter
Monthly Activity Reports	WPC Managers and Directors	End of each month
Performance Results Reports	TDEC Planning Division	End of each quarter
Annual Performance Report	USEPA	December 31
Quality Assurance Report	CO PAS	Every data batch
Responses to Comments	Commenter USEPA	30 days following responses deadline
QSSOP for Chemical and Bacteriological Sampling of Surface Water	CO PAS CO WMS WPC EFOs	Revised September
QSSOP for Macroinvertebrate Stream Surveys	CO PAS CO WMS WPC EFOs	Revised with standards
QAPP for 106 Monitoring	EFOs USEPA	Revised February
QSSOP for Periphyton Stream Surveys	CO PAS CO WMS WPC EFOs	Revised April

A7 QUALITY OBJECTIVES AND CRITERIA FOR DATA MEASUREMENT

A7.1 Data Quality Objectives

The experimental design and rationale for the division's statewide monitoring program are established in this section. All samples obtained for 106 assessments follow the protocols and quality control measures in the *QSSOP for Chemical and Bacteriological Sampling of Surface Waters (*TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). All laboratory data obtained for 106 assessments follow the protocols and quality control measures in the *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009). The specific monitoring goals and type of data are described in section A6 of this document. The data are used to fulfill the objectives for each type of monitoring strategy.

A7.2 Steps Scheduled for Specific Watershed Data Quality Objective Process

Step 1 **Define Problem** – Allocate monitoring resources for TMDL development, ecoregion reference condition definition, and 305(b) and 303(d) watershed assessments.

Step 2 **Identify Problem** – Determine monitoring needs, allocate monitoring resources, and define sampling priorities to conduct water quality assessments and develop TMDLs.

a. Monitoring

1. A combination of the 303(d) List and available models are used to determine which TMDLs are needed in a watershed. EFOs and WMS determine which waterbodies require monitoring for TMDL development, determine sampling parameters and frequencies, and station locations.
2. Ecoregional reference sites are identified in the watershed monitoring group for the fiscal year by consulting WQDB for active reference sites.
3. Waterbodies on the 303(d) List, within the watershed monitoring group, and the cause of impairment are identified.
4. Long term trend stations in EFO area of responsibility are identified.
5. Unassessed waterbodies in the watershed monitoring group for the fiscal year are identified in the ADB.
6. Assessed waterbodies of concern in the watershed monitoring group are identified in the ADB.

b. Assessment Process

Water quality assessments are completed by applying water quality criteria to the monitoring results to determine if waters are supportive of all designated uses. To facilitate this process, several provisions have been made:

1. Biological integrity, nutrient and habitat narrative guidance for wadeable streams were developed to define Fish and Aquatic Life use-support by establishing reasonable water quality expectations. These documents are referred to in the *Rules of the TDEC Division of WPC*, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WPCB, 2007). Biological data are reviewed every 3 years and acceptable metric ranges are adjusted if necessary. The division has developed a draft 10-year plan to develop nutrient guidelines for large rivers, lakes and reservoirs.

2. Numeric criteria define physical and chemical conditions that are required to maintain designated uses. The ecoregion reference dataset has helped refine DO (Arnwine and Denton, 2003) and pH (Arnwine and Denton, 2001) criteria for fish and aquatic life use support in wadeable streams.

3 The reference database has helped developed numeric translators for narrative nutrient (reference) and biological (reference) criteria.

4. To make defensible assessments, data quality objectives are met. For some parameters, a minimum number of observations are required to assure confidence in the accuracy of the assessment.

5. Provisions in the water quality criteria instruct staff to determine whether violations are caused by man-induced or natural conditions. Natural conditions are not considered pollution.

6. The magnitude, frequency and duration of violations are considered in the assessment process.

7. Waterbodies in some ecoregions naturally go dry or historically have only subsurface flow during prolonged periods of low flow. Evaluations of biological integrity attempt to differentiate whether waters have been recently dry or have been affected by man-induced conditions.

8. Waterbodies on the 303(d) List are not removed from the list until sufficient environmental data provide a rationale for delisting.

9. Ecoregion reference sites are re-evaluated and statistically tested annually. New sites are added whenever possible. Existing sites are dropped if data show the water quality has degraded, the site is not typical of the region, or does not reflect the best attainable conditions. Data from other states are used to test suitability of reference sites or to augment the database. Currently the state is reviewing river, lake and reservoir data to target reference conditions in these systems.

10. Watershed groupings are reviewed and revised if needed to ensure staffing is available for adequate coverage. Large watersheds are split when needed.

11. The TDEC Commissioner is identified in the Tennessee Water Quality Control Act as having the authority to post bodies of water based on public health concerns. The Commissioner has delegated authority to the Director of the Division of Water Pollution Control. This authority is carried out with assistance from the TWRA and the TVA. Waterbodies that are posted with fish consumption advisories are also listed on the 303(d) list of impaired waters as not supporting recreation use.

    The list of waterbodies with advisories is included in *The Status of Water Quality in Tennessee 305(b) Report* and is posted on the TDEC website. This information is also provided by TWRA in their fishing regulations. Fish are posted by species with two types of consumption advisories. The no consumption advisory targets the general population. The precautionary advisory specifies children, pregnant women and nursing mothers should not consume the fish species named while all others should limit consumption to one meal per month.

c. Future Planning:

1. Waterbodies that need additional monitoring (unassessed and insufficient data) are identified.

2. Additional resources required to complete future monitoring goals are allocated.

Step 3 **Identify Needed Analytical Measurements and Sample Handling Requirements –** Sampling information varies with sampling purpose. Table 8 lists the sampling parameters for TMDL, ecoregion, 303(d), long term trend stations, and watershed monitoring. Appendix D lists test containers, preservatives, detection limits, and holding times. The *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describe sample handling protocols.

Step 4 **Study Boundaries -** Fiscal watershed groups are illustrated in Figure 2, Table 8, and Appendix C.

Step 5 **Decision Rules -**

a. Monitoring:

The schedule for watershed monitoring (Appendix C) and resource allocation are determined using the following. Detailed information is provided in the *WPC Monitoring and Assessment Program Plan* (TDEC, 2009).

1. The *Monitoring for TMDL Development* (WMS, 2001) and the WMS manager determined TMDL monitoring requirements for specific TMDLs.
2. WQDB lists active ecoregion reference sites in each watershed group.
3. The 303(d) List identifies impaired waterbodies.
4. WQDB identifies long term monitoring stations.
5. ADB lists unassessed waterbodies.

b. Assessment (Categorization of Use Support):

To determine the uses the waterbody supports, the water quality criteria are referenced. Monitored waters are compared to the most restrictive water quality standards to determine if they meet their designated uses. Generally, the most stringent criteria are recreational use and support of fish and aquatic life.

All major rivers, streams, reservoirs and lakes have been placed into georeferencing sections called waterbody segments. Each waterbody segment has a unique identification number referencing an eight-digit watershed hydrologic unit code (HUC), plus a reach number, and an identification segment.

All available water quality data, including information from WPC, other governmental agencies, universities, and private groups are considered. However, not all data meet state quality control standards and approved collection techniques. Assessments are completed using scientifically sound monitoring methodologies. After use support is determined, waterbodies are placed in one of the following five categories recommended by EPA:

Category 1 waters are those waterbody segments, which have been monitored and meet water quality criteria. The biological integrity of Category 1 waters is comparable with reference streams in the same subecoregion and pathogen criteria are met. Previously these waterbodies were reported as fully supporting.

Category 2 waters have only been monitored for some uses and have been assessed as fully supporting of those uses, but have not been assessed for the other designated uses. Often these waterbodies have been assessed and are fully supporting of fish and aquatic life, but have not been assessed for recreational use. In previous assessments, these waters were assessed as fully supporting.

Category 3 waters have insufficient or outdated data and therefore have not been assessed. These waters are targeted for future monitoring. In previous assessments, these waterbodies were identified as not assessed.

Category 4 waters are waterbodies that have been monitored and found to be impaired for one or more uses, but a TMDL is not required. These waters are included in the 303(d) List of impaired waters. Category 4 has been subdivided into three subcategories. Previously, these waters were reported as either partially or non-supporting.

Category 4a impaired waters have had all necessary TMDLs approved by EPA.

Category 4b impaired waters do not require TMDL development because other pollution control requirements required by local, state or federal authority are expected to address all water-quality pollutants (EPA, 2003).

Category 4c waters are those in which the impacts are not caused by a pollutant (e.g. certain habitat alterations).

Category 5 waters have been monitored, and do not meet one or more water quality standards. In previous assessments, these waters have been identified as partially supporting or not supporting designated uses. Category 5 waterbodies are moderately to highly impaired by pollution and need the development of TMDLs for known impairments.

TDEC prefers to base waterbody assessments on recently collected data. Waterbody assessments completed using modeling or land use information are more difficult to defend. Given TDEC's resources, all Tennessee waterbodies cannot be assessed every two years for 305(b) reporting purposes. Therefore, monitoring and assessments are conducted on the five-year rotating schedule.

The division is increasing its reliance on rapid biological assessments, which provide a quick and accurate assessment of the general water quality and aquatic life use-support in a stream. However, biological assessments do not provide specific toxic pollutant or bacterial levels in waterbodies. The challenge in the coming years will be to combine biological assessments with chemical and bacteriological data.

c. Assessment Participants:

- Planning and Standards manager
- Watershed Management manager
- Environmental Field Office managers
- Environmental Field Office monitoring staff (environmental specialist and/or biologist)
- Watershed Management GIS personnel (geo-indexing)

In a joint effort, the PAS manager and EFO staff compare monitoring results to water quality standards and ecoregional reference data to determine if a waterbody supports its designated uses. The support (categorized use) status of each assessed waterbody is entered in the Assessment Database (ADB). Watershed Management personnel provide geo-indexing support to link the ADB assessment to a Geographic Information Systems (GIS) map with National Hydrography Dataset (NHD).

In even numbered years, after the assessments are completed, the impaired waterbodies are entered into the draft 303(d) List of impaired waters. This list is submitted to EPA for review and made available to the public on the division's website for comments. Public meetings are conducted across the state for allowing public comments on the 303(d) List. Written comments are also received.

d. Assessment Reports:

Assessment information is compiled biennially in two reports:

- 303(d) List of impaired waters in Tennessee
- 305(b) Report on the status of water quality in Tennessee

These reports are sent to EPA and made available to the public through mail outs, public meetings and the website.

e. Future Planning:

1. Review WQDB and ADB for data gaps and unresolved issues
2. Evaluate data acceptability
3. Consult with field office personnel, PAS, and WMS

Step 6 Specify Limits on Decision Rules

Detailed information concerning minimum detection limits, analytical methods, and QC requirements are included in Section B. Specific limits on decision rules are listed in Table 12. Regulatory criteria for specific parameters (analytes) are found in Table 13.

Table 12: Limits on Decision Rules

Parameter	Parameter Range	Null Hypothesis	Tolerable Limit	Consequences of Decision Error	Corrective Action	Gray Region	Probability Value
Chemical	• *Rules of TDEC Division of WPC*, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007) • *Development of Regionally-based Interpretation of Tennessee's Narrative Nutrient Criterion* (Denton, Arnwine, and Wang, 2001)	Waterbody does not exceed criteria or regional guidelines	90% of data points fall within criteria or guidelines	Placed on 303(d) List erroneously	Additional data are collected and assessment revised. Waters removed from 303(d) List.	Macroinvertebrate data indicates FAL is supporting and chemical data exceed criteria.	FAL support decision based on macroinver-tebrate results.
Bacteriological	• *Rules of TDEC Division of WPC*, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007)	Waterbody does not exceed criteria	Geomean and/or single criterion meet criteria	Placed on 303(d) List erroneously	Additional data are collected and assessment revised. Waters removed from 303(d) List.	Geomean is acceptable, but single sample exceeds criteria due to rain.	Support decision is based on criteria.
Macroinvertebrate	• *Rules of TDEC Division of WPC*, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007) • *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006)	Waterbody does not fall below regional guidelines	Index values meet or exceed regional guidelines	Placed on 303(d) List erroneously	Additional data are collected and assessment revised. Waters removed from 303(d) List.	Biorecon scores ambiguous.	Support decision is based on field, habitat, or chemical data or is considered unassessed until SQSH is collected.

Table 12: Limits on Decision Rules

Parameter	Parameter Range	Null Hypothesis	Tolerable Limit	Consequences of Decision Error	Corrective Action	Gray Region	Probability Value
Habitat	• *Rules of TDEC Division of WPC*, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007) • *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006)	Waterbody does not fall below regional guidelines	Habitat scores meet or exceed regional guidelines	Placed on 303(d) List erroneously	Additional data are collected and assessment revised.	Macroinvertebrate sample scores fully supporting and habitat assessment does not meet goals.	Support decision is based on macroinverte-brate sample.
Periphyton	• *QSSOP for Periphyton Stream Surveys (TDEC 2010)*	Waterbody does not fall below regional guidelines	Habitat scores meet or exceed regional guidelines	Placed on 303(d) List erroneously	Additional data are collected and assessment revised.	Periphyton sample scores fully supporting and habitat assessment does not meet goals.	Support decision is based on periphyton sample.

Table 13: Regulatory Criteria†

Parameter	Use	Criteria*	Citation
Alkalinity	FAL	Will not be detrimental to Fish and Aquatic Life (FAL)	*Rules of TDEC-Tennessee Water Quality Control Board*, Chapter 1200-4-3, General Water Quality Criteria (WQCB, 2007)
Aluminum, Al	FAL	Will not be detrimental to FAL	
Ammonia Nitrogen as N	FAL	Will not be detrimental to FAL	
Arsenic, As	FAL	FAL toxic substances criteria*	
	Domestic Water Supply	10 µg/L	
Cadmium, Cd	FAL	FAL toxic substances criteria*	
Chromium, Cr	FAL	FAL toxic substances criteria*	
CBOD	FAL	Will not be detrimental to FAL	
COD	FAL	Will not be detrimental to FAL	
Color, Apparent,	FAL	Will not materially affect FAL	
Color, True	FAL	Will not materially affect FAL	
Specific conductance (field)	FAL	Will not be detrimental to FAL	
Copper, Cu	FAL	FAL toxic substances criteria*	
Cyanide, Cy	FAL	FAL toxic substances criteria*	
Dissolved Oxygen (field)	FAL	• $\geq$ 5.0 mg/l for all waters except • Trout streams $\geq$ 6.0 mg/l • Naturally reproducing trout streams $\geq$ 8.0 mg/l • Ecoregion 66 $\geq$ 7.0 mg/l	
E. Coli	Recreation	• $\leq$ 126 CFU as geometric mean of 5 samples/30 days • Individual samples for reservoirs, State Scenic Rivers, Exceptional Waters or ONRW $\leq$ 487 CFU • All others individual samples $\leq$ 941 CFU	
Flow	FAL	Will be adequate to provide habitat for FAL	
Iron, Fe	FAL	Will not be detrimental to FAL	
Lead, Pb	FAL	FAL toxic substances criteria*	
	Domestic Water Supply	5 µg/L	
Manganese, Mn	FAL	Will not be detrimental to FAL	
Mercury, Hg	FAL	FAL toxic substances criteria*	
	Recreation	Organism criteria = 0.051 µg/L	
	Domestic Water Supply	2 µg/L	
Nickel, Ni	FAL	FAL toxic substances criteria*	
	Domestic Water Supply	100 µg/L	
Nitrate + Nitrite	FAL	Per *Development of Regionally-Based Interpretations of Tennessee's Narrative Nutrient Criterion* (Denton et al., 2001)	
pH (field)	FAL	Per FAL pH criteria.	
Residue, Dissolved	FAL	Will not be detrimental to FAL	

Table 13: Regulatory Criteria (Continued)†

Parameter	Use	Criteria*	Citation
Residue, Settleable	FAL	Will not be detrimental to FAL	
Residue, Suspended	FAL	Will not be detrimental to FAL	*Rules of TDEC-Tennessee Water Quality Control Board*, Chapter 1200-4-3, General Water Quality Criteria (WQCB, 2007)
Residue, Total	FAL	Will not be detrimental to FAL	
Selenium, Se	FAL	FAL toxic substances criteria*	
Sulfates	FAL	Will not be detrimental to FAL	
Temperature field	FAL	$\leq$ 30.5°C w. > 2°C change/hour Trout waters $\leq$ 20°C	
Total Hardness	FAL	Will not be detrimental to FAL	
Total Kjeldahl Nitrogen	FAL	Will not be detrimental to FAL	
Total Organic Carbon	FAL	Will not be detrimental to FAL	
Total Phosphorus	FAL	Per *Development of Regionally-Based Interpretations of Tennessee's Narrative Nutrient Criterion* (Denton et al., 2001)	
Turbidity	FAL	Will not materially affect FAL	
Zinc, Zn	FAL	FAL toxic substances criteria*	
Biorecon	FAL	Per *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006)	
SQSH	FAL	Per *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006)	
Habitat Assessment	FAL	Per *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006)	
Toxic Substances	Domestic Water Supply	Will not "affect the health and safety of man or animals, or impair the safety of conventionally treated water supplies". *	

*This is a criteria summary. For specific criteria see *Rules of TDEC-Tennessee Water Quality Control Board*, Chapter 1200-4-3, General Water Quality Criteria (WQCB, 2007).
†Minimum detection limits are included in Appendix D. QC requirements are in Table 37.

Step 7 Optimal Design for Obtaining Data

1. Develop a long-term state monitoring strategy
2. Identify monitoring objectives
3. Select a monitoring design
4. Identify core and supplemental water quality indicators
5. Develop quality management and quality assurance plans
6. Use accessible electronic data systems
7. Determine methodology for assessing attainment of water quality standards
8. Produce water quality reports
9. Conduct periodic review of monitoring program
10. Identify current and future resource needs

A7.3 Measurement of Performance Criteria for Monitoring and Analyses

The division's monitoring program is evaluated during each planning and assessment cycle to develop the most comprehensive and effective plan. The sampling and monitoring process is discussed in section B1 of this document. The specific data quality objectives and performance criteria as discussed below are expressed in terms of data quality indicators. The principal indicators are precision and accuracy, bias, representativeness, completeness, comparability, and sensitivity. A summary of data quality objectives and performance criteria are presented in Table 14.

A7.3.1 Precision and Accuracy

Precision and accuracy of all data collected is of prime importance for surface water monitoring. All data collected will be compared with the associated method's precision and accuracy capabilities outlined in the *Environmental Inorganic SOPs* (TDH, 2002-2009), and the *Environmental Organic SOPs* (TDH, 2002-2009) by the state lab. Field duplicate samples are collected at 10% of the sample sites. Duplicate chemical analyses are run on at least 10% of the samples. A precision chart for QC samples must be constructed after 20 measurements of the parameter or analyte of interest. Duplicate analysis of a standard or set of standards must be used to determine precision. An accuracy chart for QC samples must be constructed from the average and standard deviation values after 20 measurements of the parameter or analyte of interest. The QC samples must have the same standard concentration. Corrective action must be taken when the QC check exceeds the acceptance limits. The issue should be reported and documented in a bound logbook or lab notebook. Data that does not meet precision and accuracy requirements will be handled according to procedures outlined in section D1 and D2 of this document.

A7.3.2 Bias

Monitoring analyses on a check standard or set of standards over time controls bias and variability. Laboratory control charts must be constructed from the average and standard deviation values for each standard concentration used for QC. A change in the measurement on the check standard or set of standards that is persistently outside the upper control limit indicates a positive measurement bias. A change in the measurement on the check standard or set of standards that is persistently outside the lower control limit indicates a negative measurement bias. Data determined to be biased will be handled according to procedures outlined in section D3 of this document.

A7.3.3 Representativeness

The statewide monitoring program attempts to collect data that are representative of the environmental conditions being monitored. The types of monitoring are outlined in section A6 of this document. Each type of monitoring requires its own unique set of

guidelines for the type of sampling and parameters analyzed. The specific type of chemical, bacteriological, or biological sample to be collected varies with the sampling objectives. The sampling strategy for each type of monitoring is shown in Table 8 of section A6. The guidelines for collecting a representative water sample are described in Protocol A of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009). The guidelines for collecting a representative macroinvertebrate sample are described in Protocols A, F, and G of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006). The guidelines for collecting a representative periphyton sample are described in Protocols C, D, F and G of the *QSSOP for Periphyton Stream Sampling* (TDEC 2010).

A7.3.4 Comparability

Data comparability is dependent on standardization of monitoring objectives, sampling, analysis, and data reporting. This is ensured through a collaborative monitoring effort by WPC PAS, the EFOs, and TDH Laboratories. The monitoring objectives are included in the *WPC Monitoring and Assessment Program* (TDEC 2009). Standardized sampling procedures for Chemical and Bacteriological sample collection are outlined in Protocol A of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009). Standardized sampling procedures for collecting a macroinvertebrate sample are described in Protocols A, F, and G of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006). Standardized sampling procedures for collecting a periphyton sample are described in Protocols C, D, F and G of the *QSSOP for Periphyton Stream Sampling* (TDEC 2010). Quality control samples are collected at 10% of sampling events. This includes trip blanks, field blanks, duplicate samples, temperature blanks, and equipment field blanks, if applicable. Typically equipment field blanks are not checked due to the fact that WPC samples *in situ* whenever possible. All data collected are documented by the EFO responsible for collection and the laboratory responsible for the analyses and reported to WPC PAS. The data are systematically entered into the Access Water Quality Database using standardized forms illustrated in Appendix E.

A7.3.5 Completeness

The statewide monitoring program uses a 5-year watershed cycle to meet the demands of the water quality program data requirements. The watershed groups monitored in the 5-year watershed cycle are outlined in section A6 of this document. There are standard data quality objectives for each type of monitoring performed during the cycle. The percentage of valid data points relative to the total possible data points is calculated to determine the completeness of the monitoring objectives. The completeness of sampling, documentation, and chain-of-custody is ensured by using the protocols described in the *QSSOP for Chemical and Bacteriological Sampling for Surface Water* (TDEC, 2009), in the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006), and in the *QSSOP for Periphyton Stream Sampling (*TDEC 2010*)*, the *Environmental Inorganic Chemistry*

Laboratory Quality Assurance Plan (TDH, 2004), and the *Environmental Organic SOPs* (TDH, 2002-2009).

A7.3.6 Sensitivity

Method sensitivity is determined by field and laboratory performance. Several factors influence the attainable level of sensitivity of sampling, chemical, bacteriological, and biological methodology. Field personnel must demonstrate the ability to properly collect samples by using the protocols outlined in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006), and in the *QSSOP for Periphyton Stream Sampling* (TDEC 2010). Laboratory analysts must demonstrate the ability to measure analytes of interest at the minimum required detection limit of the method, the instrument detection limits, or at regulatory levels. The analytical methods and associated sensitivities are described in the *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004), and the *Environmental Organic SOPs* (TDH, 2002-2009).

Table 14: Record of Performance Criteria

Performance Criteria	Chemical and Bacteriological	Biological
Matrix	Surface water	Benthic macroinvertebrates, periphyton
Parameter	Table 8	• Biorecon • SQKICK • SQBANK • RPS • MPS
Project Action Level	*Rules of TDEC Division of WPC,* Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007)	*Rules of TDEC Division of WPC,* Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007)

Table 14: Record of Performance Criteria (Continued)

Performance Criteria	Chemical and Bacteriological	Biological
Sampling Procedure	*QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009)	*QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) *QSSOP for Periphyton Stream Survey* (TDEC, 2010)
Analytical Method/SOP	*Environmental Inorganic SOPs* (TDH, 2002-2009)*, *Environmental Organic SOPs* (TDH, 2002-2009)*, and *Standard Methods of Examination of Water and Wastewater*, 19th Edition (APHA, 1995)†	*QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) *QSSOP for Periphyton Stream Survey* (TDEC, 2010)
Precision and Accuracy	Field duplicate samples are collected at 10% of samples per *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009). Duplicate chemical analyses are run on at least 10% of the samples. Laboratory precision is addressed in *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004), *Environmental Organic SOPs* (TDH, 2002-2009)*. Precision for bacteriological analyses is addressed in *Standard Methods of Examination of Water and Wastewater*, 19th Edition (APHA, 1995)†.	Duplicate macroinvertebrate samples are collected at 10% of sites per *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) Duplicate periphyton samples are collected at 10% of sites per *QSSOP for Periphyton Stream Survey* (TDEC, 2010)

Table 14: Record of Performance Criteria (Continued)

Performance Criteria	Chemical and Bacteriological	Biological
Bias	To avoid field sampling bias all samples, trip field blanks, and duplicates are collected following *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009). Laboratory bias is addressed in *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004), *Environmental Organic SOPs* (TDH, 2002-2009)* and *Standard Methods of Examination of Water and Wastewater*, 19th Edition (APHA, 1995)†.	Duplicate macroinvertebrate samples are collected at 10% of sites. Sorting efficiency and taxonomic verification are completed on 10% of all samples per *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006). Probabilistic monitoring results are compared to targeted monitoring results to check for bias in watershed assessment. Duplicate periphyton samples are collected at 10% of sites. *QSSOP for Periphyton Stream Survey* (TDEC, 2010)
Representa-tiveness	A representative water sample is achieved by following guidelines in Protocol A of *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009).	A representative macroinvertebrate sample is collected by following guidelines in Protocols A, F, and G of Q*SSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006). Standardized sampling procedures for collecting a periphyton sample are described in Protocols C, D, F and G of the *QSSOP for Periphyton Stream Sampling* (TDEC 2010).

Table 14: Record of Performance Criteria (Continued)

Performance Criteria	Chemical and Bacteriological	Biological
Completeness	Sampling, documentation, and chain-of-custody protocols are described in *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) and *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004) and *Environmental Organic SOPs* (TDH, 2002-2009)*	Sampling, documentation, and chain-of-custody protocols are described in *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006). Sampling, documentation, and chain-of-custody protocols are described in the *QSSOP for Periphyton Stream Sampling* (TDEC 2010).
Comparability	Duplicate samples at 10% of sampling events per *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004), *Environmental Organic SOPs* (TDH, 2002-2009), and *Standard Methods of Examination of Water and Wastewater*, 19th Edition (APHA, 1995)†.	Duplicate samples at 10% of sampling events per *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) Duplicate periphyton samples are collected at 10% of sites per *QSSOP for Periphyton Stream Survey* (TDEC, 2010)
Sensitivity	*QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004), Environmental Organic SOPs (TDH, 2002-2009)*, and *Standard Methods of Examination of Water and Wastewater*, 19th Edition (APHA, 1995)†.	*QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006), *QSSOP for Periphyton Stream Survey* (TDEC, 2010)

*A complete list of TDH Environmental Laboratories Standard Operating Procedures is in the references.

† Standard Methods of Examination of Water and Wastewater, 19th Edition (APHA, 1995) is the Standard Operating Procedure for pathogen analyses only.

A8 Special Training Requirements/Certification

A8.1 Training

Specialized training requirements for this project are described in this section. This includes field sampling techniques, field analyses, laboratory analyses, assessments, and data validation. All specifically mandated training requirements are also summarized here. New staff members receive on the job training by working with experienced staff in as many different studies and sampling situations as possible. During this training period, the new employees are encouraged to perform all sample collection tasks under the supervision of an experienced staff member. Staff members have at least 6 months of field experience before selecting sampling sites, sampling alone or leading a team.

Unless prohibited by budgetary travel restrictions, statewide training is conducted at least once a year through workshops, seminars and/or field demonstrations in an effort to maintain consistency, repeatability and precision between field staff conducting surveys. This is also an opportunity for personnel to discuss problems encountered with the methodologies and to suggest SOP revisions prior to the annual SOP review.

Environmental Laboratory chemists are trained in accordance with the *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009). Environmental Laboratory aquatic biologists are trained in accordance with the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). Microbiologists are trained according to *Standard Methods for Examination of Water and Wastewater* (APHA, 1995).

The QC coordinator assures that staff members receive required training annually. Supervisors (and/or managers) assure each employee hired is qualified and properly trained. A log book of who has been trained and the type of training will be kept in each EFO. The employee's supervisor and the Department of Personnel maintain personnel records and documentation. New training requirements are communicated to EFO managers, QAPP manager, in-house QC officers, and other key personnel through email. PAS maintains records on statewide training.

- The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) lists specific qualifications and training for personnel collecting macroinvertebrate biorecon or Semi-Quantitative Single Habitat samples.

- The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) describes qualifications and training for personnel collecting chemical or bacteriological samples.

- The *QSSOP for Periphyton Stream Survey* (TDEC, 2010) describes qualifications and training for personnel collecting periphyton samples.

- The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009) provide information on analyses and data validation training requirements for laboratory personnel.

A8.2 Certifications and Credentials

Table 15 summarizes certifications and credentials required for staff members participating in this project and the timeline needed for obtaining them, if necessary. Certificates and other documentation are maintained in employee personnel files.

Table 15: Summary of Required Certifications and Credentials for Project

JOB TITLE	REQUIRED DEGREE	OTHER REQUIREMENTS INCLUDING EXPERIENCE	LIST OF PERSONNEL	OFFICAL STATION
BIOLOGIST 3	B.S. in biology	Experience equivalent to two years of full-time professional biological or related environmental specialty work in wastewater treatment, pollution control or the analyses of environmental samples or biological data.	L. Cartwright A. Goodhue B. Smith E. Vincent L. Everett L. Yates T. McCollum K. Gaddes G. Harris S. Bonney C. Perry D. Stucki D. Sparks	CO PAS NEFO JEFO JEFO KEFO KEFO TDH NLAB TDH NLAB TDH NLAB TDH NLAB TDH NLAB TDH NLAB CHEFO
BIOLOGIST 4	B.S. in biology	Experience equivalent to four years of full-time professional biological or related environmental specialty work in waste water treatment, pollution control or the analyses of environmental samples or biological data, including at least one year of supervisory or advanced working level experience in aquatic, terrestrial, or wetland biology.	D. Murray C. Augustin M. Barb B. Brown G. Overstreet P. Alicea K. Chance	KEFO-SM CLEFO CHEFO JCEFO JEFO TDH NLAB CKEFO

Table 15: Summary of Required Certifications and Credentials for Project (Continued)

JOB TITLE	REQUIRED DEGREE	OTHER REQUIREMENTS INCLUDING EXPERIENCE	LIST OF PERSONNEL	OFFICAL STATION
CHEMIST 2	B.S. in chemistry	Experience equivalent to one year of full-time work as a chemist.	E. Jeffries D. Pillow L. Satterwhite P. Wilson A. Bass M. Pattanayek J. Hitchman J. Liu J. Grosenbeck P. Leathers M. Chen A. Peeples D. Turner S. Ufegbu	TDH JLAB TDH JLAB TDH NLAB TDH NLAB TDH NLAB TDH NLAB TDH KLAB TDH KLAB TDH KLAB TDH NLAB TDH NLAB TDH NLAB TDH NLAB TDH NLAB
CHEMIST 3	B.S. in chemistry	Experience equivalent to two years of full-time work as a chemist.	L. Bonds S. Burchfield A. Wilson S. Staller	KEFO TDH NLAB TDH NLAB TDH KLAB
CHEMIST 4	B.S. in chemistry	Experience equivalent to four years of full-time work as a chemist.	C. Ayers C. Edwards R. Mitchell E. McCrary	TDH NLAB TDH NLAB TDH JLAB TDH KLAB

Table 15: Summary of Required Certifications and Credentials for Project (Continued)

JOB TITLE	REQUIRED DEGREE	OTHER REQUIREMENTS INCLUDING EXPERIENCE	LIST OF PERSONNEL	OFFICAL STATION
ENVIRONMENTAL FIELD OFFICE MANAGER	B.S. in environmental science, biology, chemistry, geology, engineering or other acceptable field	Or five years of full-time professional environmental program work, including at least one year of supervisory experience with the State of TN.	T. Templeton P. Patrick J. Holland D. Urban N. Harris R. Howard J. Horton	MEFO JEFO NEFO CHEFO KEFO CKEFO JCEFO
ENVIRONMENTAL PROGRAM MANAGER 1	B.S. in environmental science, biology, chemistry, geology, engineering or other acceptable field	Or five years of full-time professional environmental program work, including at least one year of supervisory experience with State of TN.	G. Denton S. Wang D. Owens	CO PAS CO WMS KEFO-SM
ENVIRONMENTAL PROGRAM MANAGER 2	B.S. in environmental science, biology, chemistry, geology, physics or other acceptable field	Or five years of full-time professional environmental program work, including at least two years of supervisory experience with State of TN.	P. Schmierbach	KEFO
ENVIRONMENTAL PROGRAM MANAGER 3	B.S. in environmental science, biology, chemistry, geology, physics or other acceptable field	Or five years of full-time professional environmental program work, including at least one year of managerial environmental program work with State of TN.	G. Wiggins	CO
ENVIRONMENTAL PROGRAM DIRECTOR	B.S. in environmental science, biology, chemistry, geology, physics or other acceptable field	For Executive Service positions, Minimum Qualifications, Necessary Special Qualifications, and Examination Method are determined by the appointing authority.	P. Davis	CO

Table 15: Summary of Required Certifications and Credentials for Project (Continued)

JOB TITLE	REQUIRED DEGREE	OTHER REQUIREMENTS INCLUDING EXPERIENCE	LIST OF PERSONNEL	OFFICAL STATION
ENVIRONMENTAL SPECIALIST 3	B.S. in environmental science, biology, chemistry, geology, physics or other acceptable field	Or two years of full-time professional environmental program work with the State of TN.	J. Dougan S. Kington S. Turaski J. Mann R. Cooper D. Hale S. Howell G. Horne J. Dees B. Patton J. Warren S. Hardy N. Paulsen M. Graf B. Wallace J. Lyles V. McFall B. Scott M. Robbins K. McInnes L. Barrios	JEFO JEFO- SM KEFO-SM KEFO JCEFO JCEFO CHEFO CLEFO NEFO JCEFO JCEFO MEFO MEFO CO PAS JEFO NEFO KEFO KEFO KEFO-SM CO-WMS MEFO

Table 15: Summary of Required Certifications and Credentials for Project (Continued)

JOB TITLE	REQUIRED DEGREE	OTHER REQUIREMENTS INCLUDING EXPERIENCE	LIST OF PERSONNEL	OFFICAL STATION
ENVIRONMENTAL SPECIALIST 4	B.S. in environmental science, biology, chemistry, geology, physics or other acceptable field	Or four years of full-time professional environmental program work with the State of TN.	B. Duffle A. Young K. Sparks R. Tipton B. Loudermilk R. McGahen M. Atchley M. Finks C. Doyle	NEFO CHEFO NEFO JCEFO NEFO CO WMS KEFO NEFO JCEFO
ENVIRONMENTAL SPECIALIST 5	B.S. in environmental science, biology, chemistry, geology, physics or other acceptable field	Or five years of full-time professional environmental program work with the State of TN.	D. Arnwine R. Owens B. Hall J. Burr D. Turner A. Fritz J. Smith A. Morbitt D. Duhl R. Cochran J. Innes J. Brazile	CO PAS CLEFO CKEFO KEFO KEFO-SM JEFO NEFO NEFO CO WMS CO WMS CHEFO MEFO
ENVIRONMENTAL SPECIALIST 6	B.S. in environmental science, biology, chemistry, geology, physics or other acceptable field	Or five years of full-time professional environmental program work, including at least one year of supervisory experience with the State of TN.	B. Matthews A. Rochelle L. Hoffman T. Robinson	JEFO NEFO MEFO JCEFO

Table 15: Summary of Required Certifications and Credentials for Project (Continued)

JOB TITLE	REQUIRED DEGREE	OTHER REQUIREMENTS INCLUDING EXPERIENCE	LIST OF PERSONNEL	OFFICAL STATION
ENVIRONMENTAL PROTECTION SPECIALIST 3	B.S. in engineering	Two years of full-time professional environmental engineering work.	B. Lewis	JEFO
ENVIRONMENTAL PROTECTION SPECIALIST 4	B.S. in engineering	Four years of full-time professional environmental engineering work.	D. Borders V. Steed	CO WMS CO WMS
ENVIRONMENTAL PROTECTION SPECIALIST 5	B. S. in engineering	Five years of full-time professional environmental engineering work including, at least one year in supervisory capacity.	B. Evans	CO WMS
LAB SUPERVISOR 1	Possession of a doctorate in microbiology, biology, chemistry, or public health and laboratory practices from an accredited university	For Executive Service positions – minimum qualifications, necessary special qualification, and examination method are determined by the appointing authority.	P. Singh	TDH NLAB
LAB SUPERVISOR 2 (Certified)	Possession of a doctorate in microbiology, biology, chemistry, or public health and laboratory practices from an accredited university	Two years or responsible professional health laboratory experience and licensed as a Medical Laboratory Technologist by the TDH.	O. Walker R. Atkinson	TDH JLAB, TDH KLAB
LAB SUPERVISOR 3	None	For Executive Service positions – minimum qualifications, necessary special qualification, and examination method are determined by the appointing authority.	B. Read	TDH NLAB

Table 15: Summary of Required Certifications and Credentials for Project (Continued)

JOB TITLE	REQUIRED DEGREE	OTHER REQUIREMENTS INCLUDING EXPERIENCE	LIST OF PERSONNEL	OFFICAL STATION
MICRO-BIOLOGIST 2 (Certified)	None	Licensed as a medical Laboratory Technologist and experience equivalent to one year of full-time employment performing professional microbiological work.	K. English	TDH NLAB
MICRO-BIOLOGIST 3 (Certified)	None	Licensed as a medical Laboratory Technologist and experience equivalent to two years of full-time employment performing professional microbiological work.	P. Arjmandi D. Sharp B. Price	TDH NLAB TDH JLAB TDH KLAB
MICRO-BIOLOGIST 4 (Certified)	None	Licensed as a medical Laboratory Technologist and experience equivalent to four years of full-time increasingly responsible experience performing professional microbiological work.	H. Hardin R. Pegues B. Frei	TDH NLAB TDH JLAB TDH KLAB

A9 DOCUMENTATION AND RECORDS

A9.1 Field Documentation

Required field data sheets for chemical and bacteriological samples:

- Analysis Request and Chain of Custody Form
- Flow measurement sheet (if flow is to be measured)
- Required field data sheets or field book

The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) provides field documentation and chain of custody requirements for chemical or bacteriological sampling.

Required data sheets for macroinvertebrate samples:

- Habitat assessment data sheet
- Stream survey sheet
- Macroinvertebrate assessment report (SQSH only)
- Biorecon field sheets (biorecon only)
- Site pictures (optional)
- Analysis Request and Chain of Custody Form (for samples sent to TDH Environmental Laboratories for analyses).

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) provides complete instructions on field documentation and chain of custody requirements for macroinvertebrate surveys. The *QSSOP for Periphyton Stream Surveys* (TDEC 2010) provides complete instructions on field documentation and chain of custody requirements for periphyton surveys.

A9.2 EFO Documentation

Required documentation and logs for EFOs:

- Flow meter calibration and maintenance logbook and manual
- Field water parameter meter calibration and maintenance logbook and manual
- Macroinvertebrate sample log
- Macroinvertebrate QC log (if analyzing biological samples in-house)
- Periphyton sample log and QC log
- Training Log book

A9.3 Laboratory Turnaround Time Requirements

Generally chemical and bacteriological analyses results are received from the TDH Environmental Laboratories within 25 days of receiving the sample. If results are not received in the expected time period, EFO staff or CO PAS staff contact the appropriate TDH Environmental Laboratories section manager. Chemical and bacteriological analyses results sheets are stored permanently in the WPC central office. Turnaround times for routine inorganic and organic samples is 25 business day of receipt of samples. For routine environmental microbiology samples the turnaround time is 7 business days of receipt of samples. Turnaround times for antidegradation SQSH samples are 30 days and negotiated on a project-by-project basis for other samples. Biological analytical turnaround is adjusted according to specific project deadlines and are negotiated per agreements between TDEC and TDH. (If results are needed sooner than standard turnaround times, the priority date is recorded on the Analysis Request Forms.) Biological samples are maintained for at least five years. Biological data and field sheets are stored permanently in the WPC central office.

A9.4 Laboratory Documentation

A9.4.a Chemical and Bacteriological Documentation

- Chemical and bacteriological analyses report
- Copy of sample chain of custody
- Copy of chain of custody for sample transfer
- Chemical and bacteriological sample receipt logs
- Chemical and bacteriological analyses QC logs

The TDH Environmental Laboratories produce a work order report using Microsoft Excel. The work order report (chemical and bacteriological analyses report) contains sample identification and analytical results. The *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004), the *Environmental Inorganic Laboratory SOPs* (TDH, 2002-2009), and the *Environmental Organic Laboratory SOPs* (TDH, 2002-2009) provide required laboratory documentation. Table 16 lists required chemical and bacteriological analyses results documentation.

A9.4.b Macroinvertebrate and Periphyton Documentation

- Macroinvertebrate assessment report
- Taxa list
- Semi-Quantitative Database (SQDATA) - Tennessee Core Metric query printout (SQSH only)
- Biological Sample Request and Chain of Custody Form (SQSH only)
- Biorecon field sheet (biorecon only)
- Habitat assessment sheet

- Stream survey sheet
- Sample log
- QC log
- Rapid Periphyton Survey Sheet (RPS Only)

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides detailed information about biological documentation. Table 16 lists required biological analyses results documentation.

Table 16: Data Reporting Packages

Biological Data Reporting Package	**Chemical and Bacteriological Data Reporting Package**
Taxa list	Analyses results
Macroinvertebrate assessment report	Reporting units
SQDATA - TN core metrics query	Minimum Detection Level (MDL)
Habitat assessment sheet	Method
Stream survey sheet	Laboratory performing analyses
Rapid Periphyton Survey Sheet	Analysis Request and Chain of Custody Form
Analysis Request and Chain of Custody Form	Laboratory Sample Control Log and Manifest and Inter Laboratory Chain of Custody
Biorecon field sheet (biorecons only)	

A9.5 Management and Quality Assurance

The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006), the *QSSOP for Periphyton Stream Surveys* (TDEC 2010), the *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004), and *Standard Methods for Examination of Waters and Wastewater* Part 9000 (APHA, 1995) provides quality assurance requirements.

A9.6 Audit Reports

- EFOs are audited quarterly by the QAPP Manager. (A copy of EFO Audit Report is in Appendix F).
- EPA audits TDH Environmental Laboratories every three years with a report submitted to the Commissioner of TDEC.

A9.7 Other Reports, Documents and Records

Following processing and quality control checks, chemical, bacteriological, biological, and habitat results are entered into TDEC WPCs Water Quality Database (WQDB) maintained by PAS. Annually, PAS, WMS, and EFO personnel compare results to water quality criteria and ecoregional reference data to determine use support for waterbodies

monitored in that year. The agreed upon assessments are entered into the Assessment Database (ADB).

Ultimately, the watershed monitoring, assessments, and data in the ADB are used to produce assessment reports such as *The Status of Water Quality in Tennessee 305(b) Report* (Denton, et al, 2008) and the *Final Version Year 2008 303(d) List* (TDEC, 2008) of impaired waters. TMDL monitoring results are incorporated in the TMDL. Ecoregion reference monitoring is used to refine the *Rules of the TDEC Division of WPC*, Chapter 1200-4-4, General Water Quality Criteria (TDEC-WCQB, 2007) and for assessment purposes. The division uses feedback from EPA, other state and federal agencies, as well as the private sector, to improve and enhance the reporting process.

A9.8 Data Storage and Retention

Electronic records, including the WQDB, stored on the TDEC Central Office server, are backed-up nightly on 22-cycle tape by TDEC Information Systems personnel. Monthly, the WQDB is sent electronically to the eight Environmental Field Offices and the TDH Environmental Laboratories. Paper files are permanently stored for reference in the Planning and Standards Section (Table 17). TDH Environmental Laboratories logs, instrument printouts, calibration records, and QC documents are stored at TDH Environmental Laboratories. All data records produced by TDH Environmental Organic Laboratories are stored on site for at least six years and then archived for 30 years. Paper and electronic files are stored indefinitely in the WPC central office.

Whenever revisions are made to this QAPP, the QAPP Project Manager will send both an electronic and a hard copy of the updates to the individuals identified in the distribution list in Section A3.

Table 17: Summary of Project Data Reports and Records

RECORD OR DATA TYPE*	ELECTRONIC	PAPER
Chemical and bacteriological analyses reports	WQDB STORET	Chemical/bacteriological analyses results files
Chemical and bacteriological Analysis Request and Chain of Custody Form		Chemical and bacteriological analyses results files
Flow measurement sheet (optional)	WQDB	Watershed files
Habitat assessment data sheet	WQDB	Watershed files
Stream survey sheet	WQDB	Watershed files
Macroinvertebrate assessment report	WQDB	Watershed files
Biological Analysis Request and Chain of Custody Form	WQDB	Watershed files
Biorecon and/or SQSH bench sheets	WQDB	Watershed files

Table 17: (Continued)

RECORD OR DATA TYPE*	ELECTRONIC	PAPER
Rapid periphyton survey data sheet	WQDB	Watershed files
Biorecon taxa list	NA	Watershed files
SQSH taxa list	SQDATA	Watershed files
Periphyton taxa list	SQDATA	Watershed files
Field instrument calibration		EFO logbooks
Diurnal dissolved oxygen data	Excel spreadsheet	Watershed files or EFO files
TDH Environmental Laboratories instrument calibration		TDH Environmental Laboratories
Periphyton abundance data	WQDB	Watershed files
Fish tissue data	WQDB	Fish files
Ecoregion stream data	WQDB	PAS Ecoregion files

PART B

MEASUREMENT AND DATA ACQUISITION

B1 SAMPLING PROCESS DESIGN (Monitoring Program Experimental Design)

The experimental design and rationale were established using the Data Quality Objective (DQO) Process as documented in Part A. The following sections describe implementation of design.

B1.1 Background and Design Monitoring Program Strategy

The division has a comprehensive monitoring program that serves its water quality management needs. Groundwater issues are managed by the Division of Water Supply and will be addressed in a separate document.

In 1996, WPC adopted a watershed approach that reorganized existing programs, based on management, and focused on place-based water quality management. This approach addresses all Tennessee surface waters including streams, rivers, lakes, reservoirs and wetlands. The primary goals of the watershed approach are:

- Improve water quality assessments
- Assure equitable distribution of pollutant limits for permitted dischargers
- Develop watershed water quality management strategies that integrate controls for point and non-point sources of pollution
- Increase public awareness of water quality issues and provide opportunities for public involvement

The 54 USGS eight-digit hydrologic unit codes (HUC) in Tennessee have been divided into five monitoring groups for assessment purposes. One group, consisting of between 9 and 16 watersheds, is monitored and assessed each year. This allows intense monitoring of a limited number of watersheds each year with all watersheds monitored every five years. Tennessee has completed one entire cycle and half of the second five-year cycle monitoring.

The watershed cycle provides a logical progression from data collection and assessments to TMDL development and permit issuance. The watershed cycle coincides with the development of permits issued to industries, municipalities, mining and commercial entities. The key activities involved in each five-year cycle are:

1. **Planning and Data Collection** – Existing data and reports from appropriate federal and state agencies as well as private organizations are compiled and used to describe the quality of streams, rivers, lakes, reservoirs and wetlands.

2. **Monitoring** – Field data are collected for targeted waterbodies in the watershed. These data supplement existing data and are used for water quality assessment.

3. **Assessment** – Monitoring data are compared to existing water quality standards to determine if the waterbodies support designated uses.

4. **Wasteload Allocation/Total Maximum Daily Load (TMDL)** – Monitoring data are used to determine pollutant limits for treated effluent released into the watershed by permittees. Limits are set to assure that state water quality is protected. The TMDL program identifies continuing pollution problems in the state and then determines how to solve the problem. The Total Maximum Daily Load is calculated considering all sources of pollution for the stream segment and includes a margin of error.

5. **Permits** – Issuance and expiration of all discharge permits are synchronized with watershed assessments. Approximately 1700 permits have been issued in Tennessee under the federally delegated National Pollutant Discharge Elimination System (NPDES) program.

6. **Watershed Management Plans** – Watershed management plans are developed for each watershed. The plans include a general watershed description, water quality goals, major quality concerns and issues and watershed management strategies.

This approach considers all sources of water pollution including discharges from industries and municipalities and runoff from agriculture and urban areas. Another advantage is the coordination of local, state and federal agencies and the encouragement of public participation.

B1.2 Monitoring Objectives

The purpose of the division's water quality monitoring program is to provide a measure of Tennessee's progress toward meeting the goals established in the Federal Clean Water Act and the Tennessee Water Quality Control Act. To accomplish this task, data are collected and interpreted in order to:

1. Assess the condition of the state's waters.
2. Identify problem areas with parameter values that violate Tennessee numerical or narrative Water Quality Standards.
3. Identify causes and sources of water quality problems.
4. Document areas with potential human health threats due to fish tissue contamination or elevated bacteria levels.
5. Establish trends in water quality.
6. Gauge compliance with NPDES permit limits.
7. Document baseline waterbody conditions prior to a potential impact; provide a reference stream for downstream or other sites within the same ecoregion and/or watershed.

8. Assess water quality improvements based on site remediation, Best Management Practices (BMP), and other restoration strategies.
9. Identify proper waterbody-use classification, including Antidegradation Statement implementation.
10. Identify natural reference conditions on an ecoregion basis for refinement of water quality standards.
11. Identify and protect wetlands.

B1.3 Monitoring Design

Tennessee uses several methodologies in its waterbody monitoring design. The primary monitoring design is a five-year rotational cycle based on USGS eight-digit HUC units.

B1.3.a Watersheds

The watershed approach serves as an organizational framework for systematic assessment of Tennessee's water quality. Assessing the entire drainage area as a whole, allows WPC to address water quality problems using an organized schedule and provides an in-depth study of each watershed, encouraging coordination among public and governmental organizations.

The watershed approach is a five-year cycle that has the following features:

- Commits to a monitoring strategy that results in an accurate assessment of water quality
- Synchronizes discharge permit issuance with the development of TMDLs
- Establishes TMDLs by integrating point and non-point source pollution
- Commits to two public meetings per watershed within the five-year cycle
- Partners with other agencies to obtain the most current water quality and quantity data

To attain the watershed goals mentioned above, four major objectives must be met:

- Monitoring water quality intensively within each watershed at the appropriate time in the five-year watershed cycle
- Establishing TMDLs based on best available monitoring data and sound science
- Developing a watershed water quality management plan
- Attaining good representation from all local interests at public meetings and continuing a dialogue with local interest throughout the five-year cycle

Watersheds are organized by the 54 USGS eight digit HUC codes found in Tennessee. The watersheds are addressed by groups on a five-year cycle coinciding with permit issuance and renewal. Each watershed group contains between 9 and 16 watersheds.

A typical cycle (Figure 2) will generally include:

Year 1 **Planning and Data Collection.** Existing data and reports from appropriate agencies, organizations and individuals are compiled and used to describe the quality of the state's streams, rivers, lakes, reservoirs and wetlands. Ultimately monitoring plans are developed.

Year 2 **Monitoring**. Field data are collected for key waterbodies in the watershed. Three QSSOP's were developed to guide sampling protocols and quality control: a QSSOP for macroinvertebrate surveys (TDEC, 2006), a QSSOP for chemical and bacteriological sampling (TDEC, 2009) and a QSSOP for sampling periphyton (TDEC, 2010).

Year 3 **Assessment**. Monitoring data are used to determine if the streams, rivers, lakes, reservoirs and wetlands support their designated uses and then to place the waterbodies in the appropriate category. Causes and sources of impairment are identified for waterbodies that do not meet their designated uses. Watershed public meetings are held with interested stakeholders including citizen and environmental groups, other governmental agencies, and permit holders.

Year 4 **Wasteload Allocation/Total Maximum Daily Load (TMDL).** Monitoring data are used to determine pollutant effluent limits for permittees releasing wastewater to watersheds. Limits are set to assure that water quality is protected. The TMDL program locates, quantifies and identifies continuing pollution problems in the state and then proposes solutions for the problem. TMDL documents may recommend regulatory or other actions required to resolve pollution problems. Tennessee's prioritization schedule is based on a 1998 agreement between EPA and TDEC. Under this schedule, TDEC is committed to the development of TMDLs for all waterbodies listed in the 1998 agreement by 2011. EPA committed to provide better guidance and new tools. The five steps of the TMDL process are:

1. Identify water quality problems
2. Prioritize water quality problems
3. Develop TMDL plan
4. Implement water quality improvement actions
5. Assess water quality improvement actions**.**

Year 5 **Draft Permits and Management Plans**. Issuance and expiration of all discharge permits are synchronized with watershed monitoring cycle. Draft NPDES permits are issued, public notices are released, public hearings conducted (if necessary) public notices, and permits are issued or denied. Approximately 1700 permits have been issued in Tennessee under the federally

delegated National Pollutant Discharge Elimination System (NPDES). Draft watershed management plans are developed and presented at public meetings.

Year 6 **(along with year 1 for the next cycle)** NPDES permits are issued. Each final watershed management plan, including information for each watershed, consists of a general watershed description, water quality goals, major concerns, issues and management strategies. This year the cycle begins again with planning and data collection.

More details may be found on the WPC home page http://www.state.tn.us/environment/wpc/watershed/. The watershed management groups are shown in Figure 2. Monitoring activities are coordinated with TVA, Department of Energy (DOE), Tennessee Department of Agriculture (TDA), TWRA, USGS, and USACE to avoid duplication of effort and increase watershed coverage.

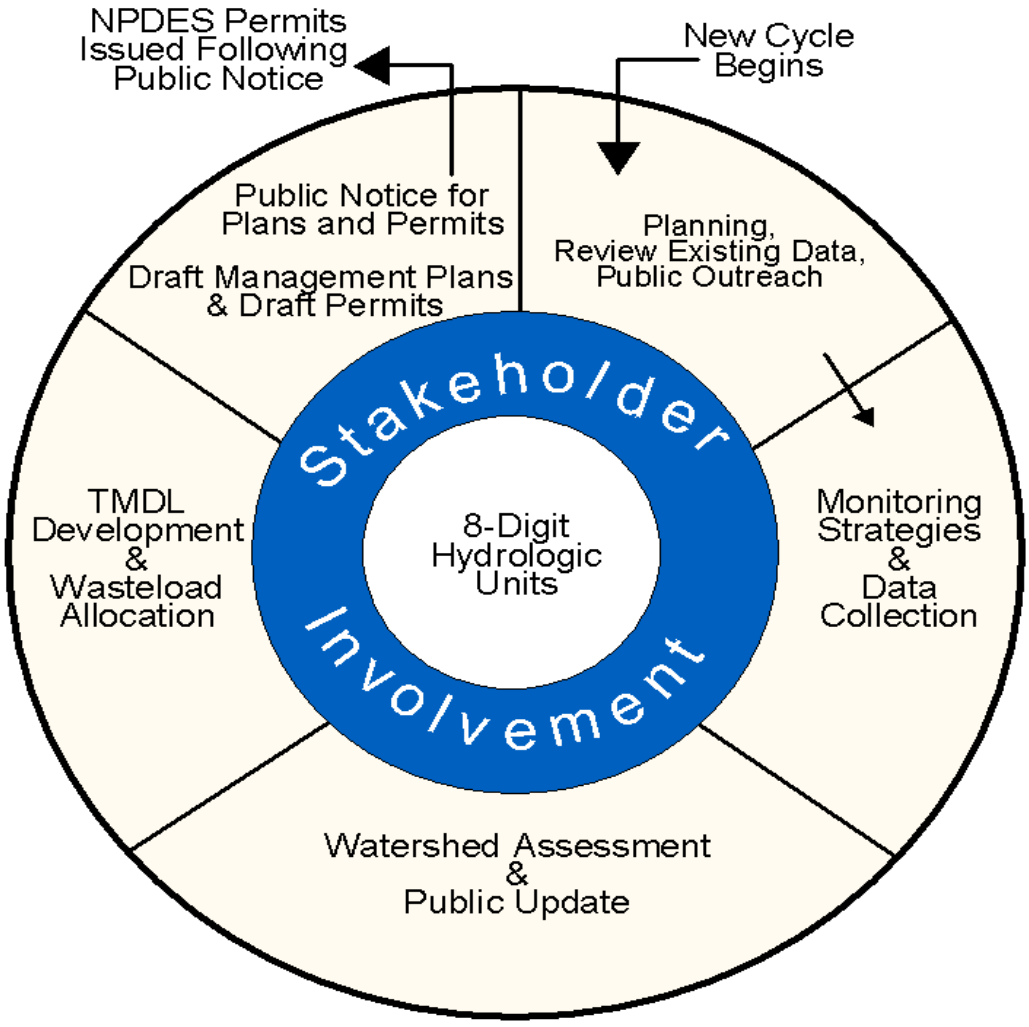


Figure 2: Graphic Representation of the Watershed Cycle

B1.3.b Ecoregions

Tennessee relies heavily on ecoregions to serve as a geographical framework for establishing regional water quality expectations (Arnwine et al, 2000). Tennessee has 31 Level IV ecological subregions in the state (Figure 3). Selection criteria for reference sites included minimal impairment and representativeness. Streams that did not flow across subregions were targeted so the distinctive characteristics of each subregion could be identified.

Three hundred and fifty-three potential reference sites were evaluated as part of the ecoregion project. The reference sites were chosen to represent the best attainable conditions for all streams with similar characteristics in a given subregion. Reference conditions represented a set of expectations for physical habitat, general water quality and the health of the biological communities in the absence of human disturbance and pollution.

Based on EPA recommendations, three reference streams per subregion were considered the minimum necessary for statistical validity. Only two streams could be found in smaller subregions. Seventy streams were targeted for intensive monitoring beginning in 1996. After analyses of the first year's data, it was determined that a minimum of five streams per subregion would be more appropriate. Where possible, additional reference streams were added. However, in smaller subregions or those with widespread human impact this was not possible. Forty-four reference streams were added to the study resulting in intensive monitoring at 114 sites beginning in the fall 1997. There were between two and eight reference streams targeted in each subregion.

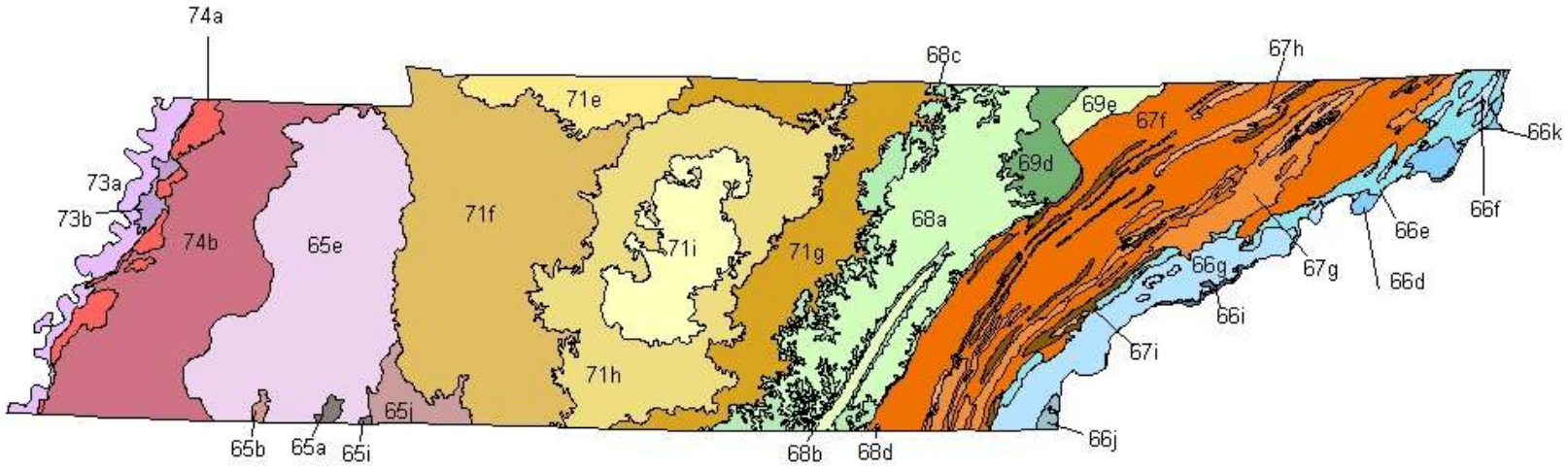
All reference sites were monitored quarterly for three consecutive years. Since 1999, sites have been monitored as part of the five-year watershed cycle. New reference sites are added, as they are located during watershed monitoring, while some of those originally selected sites have been dropped due to increased disturbances or unsuitability. This reference database has been used to establish regional guidelines for wadeable streams.

In 2007, six additional subregions were added in ecoregions 66, 68, 69 and 73 resulting in 31 Level IV ecoregions in Tennessee. In addition, the names of four subregions have been revised (65e, 66d, 69d and 73a).

With the exception of 69e, the majority of new subregions are very small or the streams originate in a different subregion. Therefore, it may not be necessary or even possible to find reference streams. Until such time as reference sites can be established these subregions will be treated as part of their original subregion and/or bioregion for assessment purposes.

B1.4 Scheduled Project Activities Including Measurement Activities

Annually, the division publishes the *Tennessee Division of Water Pollution Control Monitoring and Assessment Program Plan* (TDEC, 2009), which lists monitoring activities scheduled for the fiscal year. The program plan includes sampling locations, type and number of samples, and frequency of samples organized by environmental field office for each targeted watersheds. The division evaluates its monitoring program during each planning and assessment cycle and incorporates changes as needed to provide the most comprehensive and effective plan possible with available resources.



65a Blackland Prairie	66k Amphibolite Mountains	69e Cumberland Mountain Thrust Block
65b Flatwoods/Alluvial Prairie Margins	67f Southern Limestone/Dolomite Valleys and Low Rolling Hills	71e Western Pennyroyal Karst
65e Northern Hilly Gulf Coastal Plain	67g Southern Shale Valleys	71f Western Highland Rim
65i Fall Line Hills	67h Southern Sandstone Ridges	71g Eastern Highland Rim
65j Transition Hills	67i Southern Dissected Ridges & Knobs	71h Outer Nashville Basin
66d Southern Crystaline Ridges and Mountains	68a Cumberland Plateau	71i Inner Nashville Basin
66e Southern Sedimentary Ridges	68b Sequatchie Valley	73a Northern Holocene Meander Belts
66f Limestone Valleys and Coves	68c Plateau Escarpment	73b Northern Pleistocene Valley Trains
66g Southern Metasedimentary Mountains	68d Southern Table Plateaus	74a Bluff Hills
66i High Mountains	69d Dissected Appalachian Plateau	74b Loess Plains
66j Broad Basins		

Figure 3: Level IV Ecoregions in Tennessee

During development of the annual monitoring program plan, both Central Office and EFO staff provide input into monitoring needs.

- The monitoring program plan is reviewed to ensure all sampling and assessment priorities are addressed.
- The ADB is used to identify unassessed segments which are incorporated into the monitoring plan whenever possible.
- During plan development, Central Office and EFO staff coordinate location of monitoring stations and type of samples collected to insure adequate information is provided for TMDLs targeted for completion during that cycle.
- The location of monitoring stations is coordinated with other state and federal agencies to eliminate duplication of effort.
- At the end of each monitoring cycle, the plan is reviewed to make sure monitoring needs were covered. Uncompleted sampling or data gaps are incorporated into the next years monitoring cycle or contracted to the TDH Environmental Laboratory Aquatic Biology Section for completion.

1. Antidegradation Monitoring –

Tennessee's water quality standards require the incorporation of the antidegradation policy into regulatory decisions (Chapter 1200-4-3-.06).

As one of the elements comprising Tennessee's water quality standards, the antidegradation statement has been contained in the criteria document since 1967. EPA has required the states, as a part of the standards process, to develop a policy and an implementation procedure for the antidegradation statement. "Additionally, the Tennessee Water Quality Standards shall not be construed as permitting the degradation of high quality surface waters. Where the quality of Tennessee waters is better than the level necessary to support propagation of fish, shellfish, wildlife, and recreation in and on the water, that quality will be maintained and protected unless the state finds, after intergovernmental coordination and public participation, that lowering water quality is necessary to accommodate important economic or social development in the area in which the waters are located" (TDEC-WQCB, 2007).

A three-tiered antidegradation statement was incorporated into Tennessee's 1994 revisions. In the 1997 triennial review, the three tiers were more fully defined. A procedure for determining the proper tier of a stream was developed in 1998. The

evaluation took into account specialized recreation, scenic considerations, ecology, biological integrity and water quality.

Tennessee further refined the antidegradation statement in 2004 specifying that alternatives analysis must take place before new or expanded discharges can be allowed in Tier I waters.

In 2006 the antidegradation statement was revised and the Tier designations were replaced by the following categories.

1. "Unavailable conditions exist where water quality is at, or fails to meet, the criterion for one or more parameters. In unavailable conditions, new or increased discharges of a substance that would contribute to a condition of impairment will not be allowed."

2. "Available conditions exist where water quality is better than the applicable criterion for a specific parameter. In available conditions, new or additional degradation for that parameter will only be allowed if the applicant has demonstrated that the reasonable alternatives to degradation are not feasible."

A list of high quality waters is posted on TDEC's website at http://www.tn.us/environment/wpc/publications/hqwlist.mht. This list is updated as new high quality waters are identified

3. Exceptional Tennessee Waters are waters in which no degradation will be allowed unless that change is justified as a result of necessary economic or social development and will not interfere with or become injurious to any classified uses existing in such waters. Exceptional Tennessee Waters are:

* Waters within state or national parks, wildlife refuges, wilderness areas or natural areas.
* State Scenic Rivers or Federal Wild and Scenic Rivers.
* Federally-designated critical habitat or other waters with documented non-experimental populations of state or federally-listed threatened or endangered aquatic or semi-aquatic plants or animals.
* Waters within areas designated Lands Unsuitable for Mining.
* Streams with naturally reproducing trout.
* Waters with exceptional biological diversity as evidenced by a score of 40 or 42 on the TMI (or a score of 28 or 30 in subregion 73a), provided that the sample is considered representative of overall stream conditions.
* Other waters with outstanding ecological, or recreational value as determined by the department.

4. Outstanding National Resource Waters (ONRW). These ETWs constitute an outstanding national resource due to their exceptional recreational or ecological significance.

2. **TMDL Development Monitoring** – Monitoring for a minimum of two TMDLs is scheduled in each EFO. The number and location of monitoring stations vary by drainage area and possible pollutant sources. The document *Monitoring to Support TMDL Development* (TDEC, 2001) and the WMS manager are consulted for specific monitoring needs. Table 18 lists typical monitoring required for TMDL development.

Table 18: Minimum TMDL Monitoring

TMDL	Matrix	Analyses	Field Parameters	Flow	Frequency	Number of Data Points
Metals	Water	Hardness ($CaCO_3$) TSS TOC Metals†	pH Temperature Specific conductance DO	Yes	Monthly	Min. 12
PH	Water	Acidity, Total Alkalinity, Total TSS Hardness ($CaCO_3$) TOC	pH Temperature Specific conductance DO	Yes	Monthly	Min. 12
DO	Water	$CBOD_5$ $CBOD_u$ NH_3 NO_2NO_3 TKN Phosphorous, Total	pH Temperature Specific conductance DO	Yes	Monthly (DO can be diurnal)	Min. 12
			Diurnal DO		1-2 (Low Flow)	Min. 14 days
Nutrients	Water	NH3 NO_2NO_3 TKN Phosphorous, Total TSS Turbidity TOC Orthophosphate Periphyton	pH Specific conductance Temperature DO	Yes	Monthly	Min 12 (at least 1 high flow/quarter)min. 4 high-flow
			Diurnal DO		1-2 (Low Flow)	Min. 14 days
Pathogens	Water	Fecal coliform E. coli TSS Turbidity	pH Temperature Specific conductance DO	Yes measured if wadeable, estimated if large river (Per Sherry Wang 4/3/09)	Monthly	Min 12 (at least 1 high flow/quarter)min. 4 high-flow

**Monitoring to Support TMDL Development* (TDEC, 2001) provides additional information.
†Metal(s) on the 303(d) List

3. **Ecoregional Reference Stream Monitoring** - Reference stream monitoring is performed at the established ecoreference site in the appropriate watershed group. Reference streams are sampled every 5 years coinciding with the watershed cycle. If watershed screening indicates a potential new reference site, more intensive protocols are used to determine potential inclusion in the reference database. The division's monitoring program plan (TDEC, 2009) lists the ecoregion stations. Table 19 specifies ecoregion reference stream monitoring requirements.

Table 19: Ecoregion Reference Stream Monitoring Requirements

Annually	**Spring and Fall**	**Quarterly Monitoring (Summer, Fall, Winter, and Spring)**			
Periphyton	**Benthic Macroinver-tebrate**	**Water Field Parameter**	**Water Chemical Parameters**	**Water Bacteriological Parameters**	**Stream Flow**
MPS	Biorecon	DO	Alkalinity	*E. Coli*	X
RPS	SQSH	pH	Ammonia Nitrogen as N	Fecal Coliform	
	Habitat Assessment	Temperature	Arsenic, As	Enterococcus	
		Specific conductance	Cadmium, Cd		
			Chromium, Cr		
			Color, Apparent,		
			Color, True		
			Copper, Cu		
			Iron, Fe		
			Lead, Pb		
			Manganese, Mn		
			Nitrate + Nitrite		
			Residue, Dissolved		
			Residue, Suspended		
			Sulfates (69d and 68a only)		
			Total Hardness		
			Total Kjeldahl Nitrogen (low level)		
			Total Organic Carbon		
			Total Phosphorus (low level)		
			Turbidity		
			Zinc, Zn		

4. **Long Term Trend Station Monitoring –** At least quarterly, chemical and bacteriological samples are collected and field water parameter measurements are taken at long term trend stations (Table 20). The division's program plan (TDEC, 2009) lists the long term trend stations.

Table 20: Long Term Trend Monitoring Requirements

Field Water Parameters	Chemical Parameters	Bacteriological Parameters
Specific conductance	Alkalinity	*E. coli*
DO	Aluminum, Al	Fecal coliform
pH	Ammonia	
Temperature	Arsenic, As	
Flow	Cadmium, Cd	
	Chromium, Cr	
	CBOD	
	Color, Apparent	
	Color, True	
	Copper, Cu	
	Cyanide, Cy	
	Iron, Fe	
	Lead, Pb	
	Manganese, Mn	
	Mercury, Hg	
	Nickel, Ni	
	Nitrate + Nitrite	
	Residue, Dissolved	
	Residue, Settleable	
	Residue, Suspended	
	Residue, Total	
	Selenium, Se	
	Sulfates	
	Total Hardness	
	Total Kjeldahl Nitrogen	
	Total Organic Carbon	
	Total Phosphorus	
	Turbidity	
	Zinc, Zn	

5. **Monitoring for 303(d) Listed Waterbodies -** Impaired waters should be monitored, at a minimum, every five years coinciding with the watershed cycle. Ideally, waters that do not support fish and aquatic life should be sampled once for macroinvertebrates (semi-quantitative sample preferred) and monthly for the listed pollutant(s). It is preferred that streams with impacted recreational uses, such as those impaired due to pathogens, be sampled monthly for *E. coli.* and also that *E. coli* be sampled 5 times within a 30-day period, but either could be sampled. Another sampling strategy could be bimonthly during the prime water contact season.

However, resource limitations or data results may sometimes necessitate fewer sample collections. For example, there are cases where pollutants are at high enough levels

that sampling frequency may be reduced while still providing a statistically sound basis for assessments. In some other cases, monitoring may be appropriately bypassed during a monitoring cycle.

a. 303(d) Listed sites requiring no additional monitoring

There are individual sites where conditions may justify retaining the impaired status of the stream without additional sampling during an assessment cycle. The reasons may include, but are not limited to, the following:

- Data have been collected by the division or another agency within the last five years and water quality is not thought to have changed.

- Another agency or a discharger has accepted responsibility for monitoring the stream and will provide the data to the division. During the planning process for each watershed cycle, field staff should recommend to the permitting section those streams where it would be appropriate that impaired streams be sampled by a discharger. Where permits are up for renewal, such conditions could be added.

- The stream is known to be dry or without flow during the majority of the year that sampling is being scheduled.

- The stream is impacted by legacy pollutants, such as bioaccumulative substances and/or sediment contamination, and conditions are unlikely to have changed.

- The stream is absent point source discharges or issuance of ARAP permits for physical alterations and there has been no substantial change in land use since the last sampling event (including stream impoundments). Data have been collected within the last five years.

- A TMDL has been approved for the stream within the last five years, but control strategies have not been implemented.

All impaired streams in targeted watersheds must be accounted for in the annual monitoring program plan. If a field office is proposing to bypass monitoring of an impaired stream, an appropriate rationale must be provided and included in the program plan. Streams may not be bypassed two assessment cycles in a row. Should an impaired stream be dry during two consecutive cycles, consideration should be given to requesting the stream be delisted on the basis of low flow.

b. Impaired streams where additional sampling may be limited or discontinued

There are individual sites where initial results may justify a discontinuation of sampling. The reasons are limited to the following:

- Emergency resource conditions may require that sampling be restricted after a monitoring cycle is initiated, but before it is completed. Discontinuation of monitoring on this basis must be approved in advance by the Deputy Director or Director. Appropriate reasons may include loss of critical personnel, hiring freezes, or budgetary spending freezes. Before requesting a halting of sampling in impaired streams, assistance from the Department of Health's Aquatic Biology section is considered. Such requests are coordinated through WPC PAS.

- Initial stream sampling documents elevated levels of pollutants indicating, with appropriately high statistical confidence, that the applicable water quality criteria are still being violated. (Note – rain event sampling is inappropriate)

The levels of pollutants that indicate continued water quality standards violations with statistical confidence are provided in Table 21. For example, if three samples are collected and all three values exceed the levels in the far right hand column, then sampling for that parameter may be halted, as there is a very high probability that criteria would be exceeded in future sampling. If all three samples do not exceed the level provided in the table, then at least four more samples must be collected. If all seven samples exceed the levels in the middle column of the table, then sampling may cease. If all seven samples do not exceed the value in the table, then all sampling must be completed.

Important notes about this process:

- This process only applies to chemical parameters or bacteriological results. Streams impacted by poor biology, habitat alterations, or siltation due to habitat alterations must still be monitored at least once (habitat assessment, plus SQSH or biorecon).

- Rain event samples cannot be used to justify a reduction in sampling frequency.

- The division is not establishing new criteria with Table 21 and the numbers in the table should not be used independently to assess streams. These numbers, which are based on the actual criteria, simply indicated the statistical probability that the criteria have been exceeded by a dataset when the numbers of observations are considered.

- Where streams are impacted by multiple pollutants, all parameters must exceed the values in Table 21 before sampling can be halted.

Table 21: 303(d) Sampling Frequency Schedule (Matrixes for all samples are water.)

Nutrient Sampling			
Nitrite-Nitrate	**Minimum Number of Date Points†**		
	10	7	3
73a	< 0.49	0.49 - 0.68	>0.68
74a, 65j, 68a	< 0.28	0.28 - 0.40	>0.40
74b	< 1.49	1.49 - 2.08	>2.08
65a, 65b, 65e, 65i	< 0.43	0.43 - 0.60	>0.60
71e	< 4.35	4.35 - 6.09	>6.09
71f	< 0.32	0.32 - 0.56	>0.56
71g, 71h, 71i	< 1.15	1.15 - 1.61	>1.61
68b	< 0.54	0.54 - 0.75	>0.75
69d	< 0.34	0.34 - 0.47	> 0.47
67f, 67g, 67h, 67i	< 1.53	1.53 - 2.14	>2.14
66d	< 0.63	0.63 - 0.88	>0.88
66e, 66f, 66g, 68c	<0.38	0.38 - 0.54	>0.54
Total Phosphate	**Minimum Number of Date Points†**		
	10	7	3
73a	<0.25	0.25 - 0.44	>0.44
74a	<0.12	0.12 - 0.21	>0.21
74b	<0.10	0.1 - 0.18	>0.18
65a, 65b, 65e, 65i, 65j, 71e, 68b, 67f, 67h, 67i	<0.04	0.04 - 0.07	>0.07
71f, 71g	<0.03	0.03 - 0.053	>0.053
71h.71i	<0.18	0.18 - 0.32	>0.32
68a, 68c, 69d, 66f	<0.02	0.02 - 0.035	>0.035
67g	<0.09	0.09 - 0.16	>0.16
66d, 66e, 66g	<0.01	0.01 - 0.018	>0.018
Pathogen Sampling			
E Coli	**Minimum Number of Date Points†**		
	10	7	3
Statewide	<941	941 - 1647	>1647

Table 21: 303(d) Sampling Frequency Schedule (Continued)

Metals Sampling			
Metals	**Minimum Number of Date Points†**		
	10	7	3
Chromium (hexavalent)	<11	11 - 19.5	>19.5
Mercury	<0.77	0.77 - 1.35	>1.35
Aluminum	<338	338 - 592	>592
Iron	<1218	1218 - 2132	>2132
Manganese	<185	185 - 325	>325
Copper* 65e, 65j, 66d, 66e, 66g, 68a, 74b	<1.25	1.25 - 2.19	>2.19
Copper* 66f, 71f	<4.44	4.44 - 7.77	>7.77
Copper* 67f, 67h, 67i, 68b, 68c, 71g, 71h, 73a	<11.6	11.6 - 20.3	>20.3
Copper* 67g, 71e, 74a	<18.0	18.0 - 31.5	>31.5
Lead* 65e, 65j, 66d, 66e, 66g, 68a, 74b	<0.19	0.19 - 0.33	>0.33
Lead* 66f, 71f	<1.02	1.02 - 1.79	>1.79
Lead* 67f, 67h, 67i, 68b, 68c, 71g, 71h, 73a	<3.51	3.15 - 6.14	>6.14
Lead* 67g, 71e, 74a	<6.07	6.07 - 10.6	>10.6
Zinc* 65e, 65j, 66d, 66e, 66g, 68a, 74b	<16.8	16.8 - 29.4	>29.4
Zinc* 66f, 71f	<58.9	58.9 - 103	>103
Zinc* 67f, 67h, 67i, 68b, 68c, 71g, 71h, 73a	<153	153 - 268	>268
Zinc* 67g, 71e, 74a	<237	237 - 415	>415
Total Suspended Solids Sampling			
Total Suspended Solids (TSS)	**Minimum Number of Date Points†**		
	10	7	3
65a, 67i, 73a	<64	64 - 112	>112
65e, 65i, 74b	<29	29 - 51	>51
65b, 67g, 68c, 71e, 71g, 71i, 74a	<13	13 - 23	>23
65j, 66d, 66e, 66f, 66g, 67f, 67h, 68a, 68b, 69d, 71f, 71h	<10	10 - 18	>18
Biological Monitoring**			
Statewide	Minimum number of data point†		
SQSH (preferred) or biorecon	1		
Habitat assessment	1		

† Field parameters are recorded when samples are collected.

*Dependent on Hardness

**Biological monitoring is not required if pathogens are the only contaminants listed.

6. **Monitoring for Watershed Screenings –** Once antidegradation, TMDL, ecoregion reference, 303(d), and long term trend stations sampling conditions are completed, each EFO monitors as many additional stations as possible to increase the percentage of assessed waterbodies. Emphasis is placed on waterbody segments that have not previously been assessed. Sampling locations are located near the mouth of each tributary if possible. Minimally, a biorecon sample is collected and a habitat assessment is completed. If impairment is observed, and time and priorities allow, additional sites are located upstream of the impaired water reach to define the impairment length. When waterbodies are assessed for recreational uses, bacteriological samples are collected. Table 22 details monitoring requirements for watershed screenings.

Table 22: Watershed Screening Monitoring Requirements

Designated Use	Parameter	Matrix	Frequency	Minimum Number of Data Points
Fish and Aquatic Life	Biorecon (or SQSH)	Macroinverte-brate	1	1
	Habitat Assessment	Physical Habitat		
	Field Parameters	Water		
	Chemical* (optional)	Water		
	Periphyton (optional)			
Recreation	E. coli	Water	Monthly	10

*Table 8 lists recommended watershed screening parameters.

7. **Fish Tissue Monitoring -** Fish tissue samples are often the best way to document chronic low levels of persistent contaminants. In the mid-1980's, sites were selected that had shown significant problems in the past and would benefit from regularly scheduled monitoring. Other stations are periodically monitored to obtain baseline information. A list of established fish tissue stations appears in Table 23. Fish tissue monitoring is planned by a workgroup consisting of staff from TDEC (WPC and DOE-Oversight), TVA (Tennessee Valley Authority), TWRA (Tennessee Wildlife Resources Agency), and ORNL (Oak Ridge National Laboratory). The workgroup meets annually to discuss fish tissue monitoring needs for the following fiscal year. Data from these surveys help the division assess water quality and determine the issuance of fishing advisories.

   TVA routinely collects fish tissue from reservoirs they manage. ORNL collects fish tissue samples from rivers and reservoirs that receive drainage from the Department of Energy Property in Oak Ridge. TWRA provides fish tissue samples to TDEC that are collected during population surveys. TDEC contracts other needed field collections and analysis to the Aquatic Biology Section, Tennessee Department of Health. Targeted fish are five game fish, five rough fish and five catfish of the same species. Samples are generally composited, although large fish may be analyzed

individually. Only fillets (including belly flap) are analyzed. Table 24 includes parameters to be analyzed.

Table 23: Fish Tissue Monitoring Stations

STATION ID	RESERVOIR NAME/STREAM NAME	LOCATION	PARAMETER	LAST FY SAMPLED	SAMPLING AGENCY
BEECH000.5WE	Beech Ck	Beech Creek embayment	Metals, Organics, Dioxin, PCBS	1995	TDEC
BEECH002.0WE	Beech Ck	U/S Morrison Creek	Organics, PCBS	1994	TDEC
BEECH036.0HE	Beech Res	Near Lexington	Metals	2006	TVA
BFORK002.5WA	Barren Fork Rv	Near Spring Cave McMinnville	Metals, Organics, PCBS	1995	TDEC
BFORK005.0FR	Tims Ford Res/Boiling Fork	Hwy 41 at Manchester	Metals, Organics, Dioxin, PCBS	1993	TDEC
BRADL000.0CE	Woods Res/Bradley Ck	Bradley Creek Embayment	PCBS	1989	TDEC
BRUMA000.0FR	Woods Res/Brumalow Ck	200' U/S old Brick Church Rd	Metals, Organics, PCBS	2007	AEDC
BSAND007.4HN	Kentucky Res/Big Sandy Rv	D/S Poplar Creek	Metals, Organics, PCBS	2008	TVA
BUFFA017.7PE	Buffalo Rv	Old Hwy 14 D/s Lobelville	Metals, Organics, PCBS	2006	TVA
BUFFA026.0PE	Buffalo Rv	U/S Lobelville STP	Metals	2008	TWRA
BUFFA041.0PE	Buffalo Rv	Hwy 412 Linden	Metals	2008	TWRA
BUFFA073.1WE	Buffalo Rv	Hwy 13 near Flatwoods	Metals	2008	TWRA
BUFFA098.1LS	Buffalo Rv	Hwy 99 near Oak Grove	Metals	2008	TWRA
CFORK028.0DB	Center Hill Res	near Center Hill Dam	Metals, Organics, PCBS	1999	TVA

Table 23: Fish Tissue Monitoring Stations (Continued)

STATION ID	RESERVOIR NAME/STREAM NAME	LOCATION	PARAMETER	LAST FY SAMPLED	SAMPLING AGENCY
CFORK058.9DB	Center Hill Res	Hwy 70/ Sligo Bridge	Metals, Organics, Dioxin, PCBS	1994	TDEC
CHATT000.9HM	Chattanooga Ck	Rendering Plant	Metals, Organics, Dioxin, PCBS	1999	TDEC
CLINC002.3RO	Watts Bar Res/Clinch Rv	Brashear Island	Metals, Organics	2004	DOE
CLINC006.8RO	Watts Bar Res/Clinch Rv	U/S Young Creek	Metals	2003	TVA
CLINC010.0RO	Watts Bar Res/Clinch Rv	D/S Gallaher Bridge	Metals	2007	DOE
CLINC014.5RO	Watts Bar Res/Clinch Rv	U/S East Fork Poplar Creek	Metals	2003	DOE
CLINC017.9RO	Watts Bar Res/Clinch Rv	Grubbs Island	Metals	2003	DOE
CLINC019.0RO	Watts Bar Res/Clinch Rv	Jones Island	Metals,	2009	DOE
CLINC022.0RO	Watts Bar Res/Clinch Rv	U/S Hwy 321	Metals	2005	TVA
CLINC024.0RO	Melton Hill Res/Clinch Rv	1 mi U/S Melton Hill Dam	Metals, Organics, PCBS	2009	TVA
CLINC043.5AN	Watts Bar Res/Clinch Rv	Solway Bridge	Metals	2007	DOE
CLINC045.0AN	Melton Hill Res/Clinch Rv	Near Hwy 62	Metals, Organics, PCBS	2009	TVA
CLINC048.0AN	Melton Hill Res/Clinch Rv	Bull Run Steam Plant	Metals,	2004	DOE
CLINC080.0CA	Norris Res/Clinch Rv	Near Dam	Metals, Organics, Dioxin, PCBS	2008	TWRA
CLINC120.5UN	Norris Res/Clinch Rv	Hwy 33	Metals	2008	TWRA
CLINC125.0CL	Norris Res/Clinch Rv	D/S Straight Creek	Metals	2008	TWRA
CLINC172.4HK	Clinch Rv	D/S Swan Island	Metals, Organics, PCBS	2006	TVA

Table 23: Fish Tissue Monitoring Stations (Continued)

STATION ID	RESERVOIR NAME/STREAM NAME	LOCATION	PARAMETER	LAST FY SAMPLED	SAMPLING AGENCY
CUMBE185.7DA	Cheatham Res/Cumberland Rv	Bordeaux Bridge	Metals, Organics, Dioxin, PCBS	2007	TDEC
CUMBE191.1.DA	Cheatham Res/Cumberland Rv	Shelby Street Bridge	Metals, Organics, PCBS, Dioxin	2007	TDEC
CUMBE216.2DA	Old Hickory Res/Cumberland Rv	Near dam	Metals, Organics, Dioxin, PCBS	1993	TDEC
DUCK002.0HU	Kentucky/Duck Rv	Embayment	Metal, Organics, PCBS	2008	TWRA
DUCK026.0HU	Duck Rv	D/S Tumbling Creek	Metal, Organics, PCBS	2006	TVA
DUCK032.2HI	Duck Rv	Hwy 22 near Only	Metal, Organics, PCBS	2008	TWRA
DUCK064.0HI	Duck Rv	Hwy 50, D/S Centerville	Metal, Organics, PCBS	2008	TWRA
DUCK113.9MY	Duck Rv		Metal, Organics, PCBS	2008	TWRA
EFPOP007.0RO	East Fork Poplar Ck	U/S Gum Hollow Road	Metals, Organics, Dioxin, PCBS	1998	TDEC
ELK036.5GS	Elk Rv	Prospect	Metals, Organics, PCBS	2008	TDEC
ELK077.1LI	Elk Rv	Off Hwy 273 D/S Fayetteville	Metals, Organics, PCBS	2008	TDEC
ELK150.0FR	Tims Ford Res/Elk Rv	Hwy 41, Maple Bend	Metals, Organics, PCBS	2006	TVA
ELK176.0FR	Woods Res/Elk Rv	Near Hwy 127 causeway	Metals, Organics, PCBS	1999	TDEC

Table 23: Fish Tissue Monitoring Stations (Continued)

STATION ID	RESERVOIR NAME/STREAM NAME	LOCATION	PARAMETER	LAST FY SAMPLED	SAMPLING AGENCY
FBROA051.0JE	Douglas Res/French Broad Rv	Near Indian Creek and Douglas Estates	Metals, Organics, PCBS	2008	TVA
FBROA061.0CO	Douglas Res/French Broad Rv	Taylor Bend D/S Allen Creek	Dioxin	1993	TDEC
FBROA071.4CO	Douglas Res/French Broad Rv	Rankin Bridge	Metals, Organics, Dioxin, PCBS	2007	TDEC
FBROA077.5CO	French Broad Rv	Hwy 321 bridge at junction with Hwy 160 NE of Newport	Metals	2007	TWRA
FBROA083.5CO	French Broad Rv	Hwy 70 east of Newport	Metals, Organics, Dioxin, PCBS	2008	TDEC
FBROAD033.0SV	Douglas Res/French Broad Rv	Near dam	Metals, Organics, Dioxin, PCBS	2008	TWRA
FWATE005.2PU	Center Hill Res/Falling Water Rv	U/S Cookeville Boatdock	Metals, Organics, PCBS	1993	TDEC
HARPE110.7WI	Harpeth Rv	D/S General Smelting	Metals	1999	TDEC
HATCH001.2TI	Hatchie Rv		Metals, Organics, PCBS	2007	TWRA
HIWAS007.4ME	Chickamauga Res/Hiwassee Rv	Bridge on TN Hwy 58	Metals, Organics, PCBS	2008	TVA
HIWAS012.0BR	Chickamauga Res/Hiwassee Rv	Near Rogers Creek	Metals	1990	TVA
HIWAS015.4MM	Chickamauga Res/Hiwassee Rv	I-75, D/S/ Bowaters	Metals, Organics, Dioxin, PCBS	2006	TDEC
HIWAS018.6MM	Chickamauga Res/Hiwassee Rv	U/S Hwy 11 Bridge	Metals, Organics, Dioxin, PCBS	2008	OCEAN
HIWAS037.0PO	Hiwassee Rv	Patty Station Road	Metals	2008	TVA
HOLST121.0HS	Holston Rv	Phipps Bend	Metals	2007	TWRA

Table 23: Fish Tissue Monitoring Stations (Continued)

STATION ID	RESERVOIR NAME/STREAM NAME	LOCATION	PARAMETER	LAST FY SAMPLED	SAMPLING AGENCY
HOLST131.5HS	Holston Rv	Near Goshen Valley bridge	Metals	2007	TWRA
HOLST135.0HS	Holston Rv	D/S Holston Army Ordinance near Goshen Valley	Metals, Organics, Dioxin, PCBS	2007	TDEC
LITTL001.0BT	Fort Loudon/Little River	Near East Topside Road	Metals, Organics, Dioxin, PCBS	1993	TDEC
LOOSA001.5SH	Loosahatchie Rv	Benjestown Road	Metals, Organics, Dioxin, PCBS	1997	TDEC
LOOSA005.0SH	Loosahatchie Rv	Watkins Rd	Metals, Organics, Dioxin, PCBS	1998	TDEC
LOOSA017.0SH	Loosahatchie Rv	Hwy 14	Metals, Organics, Dioxin, PCBS	1998	TDEC
LTENN001.0LO	Tellico Res/Little Tennessee River	At dam	Metals, Organics, PCBS	2008	TVA
LTENN015.0LO	Tellico Res/Little Tennessee River	U/S Baker Creek	Metals, Organics, PCBS	2006	TVA
MCKEL001.8SH	McKellar Lake	McKellar Lake	Metals, Organics, Dioxin, PCBS	2006	TWRA
MISSI724.6SH	Mississippi Rv	Memphis South Plant	Metals, Organics, Dioxin, PCBS	2007	TWRA
MISSI735.0SH	Mississippi Rv	I-40	Metals, Organics, Dioxin, PCBS	2006	TWRA
MISSI754.0TI	Mississippi Rv	Meeman-Shelby S.P.	Metals, Organics, Dioxin, PCBS	1998	TWRA
MISSI786.0LE	Mississippi Rv	Osceola	Metals, Organics, Dioxin, PCBS	2008	TWRA

Table 23: Fish Tissue Monitoring Stations (Continued)

STATION ID	RESERVOIR NAME/STREAM NAME	LOCATION	PARAMETER	LAST FY SAMPLED	SAMPLING AGENCY
MISSI817.8LE	Mississippi Rv	Blytheville	Metals, Organics, Dioxin, PCBS	2008	TWRA
MISSI838.5LA	Mississippi Rv	I-55 near Caruthersville	Metals, Organics, Dioxin, PCBS	2008	TWRA
MISSI873.0LA	Mississippi Rv	Tiptonville	Metals, Organics, Dioxin, PCBS	2006	TWRA
NFFDE009.8DY	North Fork Forked Deer Rv	Hwy 412 Linden	Metals	2008	TDEC
NFFDE020.5DY	North Fork Forked Deer Rv	Hwy 104	Metals, Organics, PCBS	2008	TDEC
NFHOL004.6SU	North Fork. Holston Rv	Brat Cloud Ford	Metals	2005	TVA
NOLIC008.5HA	Nolichucky Rv	Hurley Island	Metals	2009	TVA
NOLIC072.5WN	Nolichucky Rv	Jonesboro Water Plant Intake	Metals, Organics, PCBS	1992	TDEC
OBEY008.0CY	Dale Hollow Res/Obey Rv	Near dam	Organics, Dioxin, PCBS	1993	TDEC
OBION002.0DY	Obion River	Near Hwy 181	Metals, Organics, Dioxin	2007	TWRA
OCOEE012.5PO	Parksville Res/Ocoee Rv	Near dam (Ocoee # 1)	Metals, Organics	2008	TVA
OCOEE014.0PO	Parksville Res/Ocoee Rv	Near FR 17 (Ocoee #1)	Metals, Organics	1992	TDEC
OCOEE031.0PO	Parksville Res/Ocoee Rv	Near Tumbling Creek (Ocoee #3)	Metals, Organics, Dioxin, PCBS	1994	TDEC
PIGEO008.2CO	Pigeon Rv	Tannery Island	Metals, Organics, Dioxin, PCBS	2009	TDEC
PIGEO016.5CO	Pigeon Rv	Denton Greasy Cove Road	Metals, Organics, Dioxin, PCBS	1999	TDEC
PIGEO024.7CO	Pigeon Rv	Waterville Powerhouse	Metals, Organics, Dioxin, PCBS	1996	TDEC

Table 23: Fish Tissue Monitoring Stations (Continued)

STATION ID	RESERVOIR NAME/STREAM NAME	LOCATION	PARAMETER	LAST FY SAMPLED	SAMPLING AGENCY
POPLA000.1RO	Watts Bar Res/Poplar Ck	Watts Bar Embayment D/S DOE-25 plant	Metals, Organics, PCBS	1998	TDEC
POWEL030.0UN	Norris Reservoir/Powell Rv	Stiners Woods	Metals	2007	TWRA
REELF00002LA	Reelfoot Lake	Rays Camp	Metals, Organics, Dioxin	1993	TDEC
REELF000030B	Reelfoot Lake	Indian Crrek Embayment	Metals, Organics, Dioxin	1993	TDEC
REELF000050B	Reelfoot Lake	Walnut Log Ditch	Metals, Organics, Dioxin	1993	TDEC
RICHL024.3GS	Richland Creek	Pulaski, U/S Lowhead dam and STP	Metals	2008	TDEC
ROLLI000.0FR	Woods Res/Rollins Ck	Embayment	Metals, Organics, Dioxin, PCBS	2008	TDEC
SEQUA023.0MI	Sequatchie River	Near Whitwell	Metals	2008	TDEC
SEQUA048.8SE	Sequatchie River	Hwy 111 near Dunlap	Metals	2008	TDEC
SFHOL001.1SU	South Fork Holston River	Ridgefields Bridge in Kingsport	Metals, Organics, Dioxin, PCBS	2008	TDEC
SFHOL002.9SU	South Fork Holston River	Hwy 126 bridge near Kingsport	Metals, Organics, Dioxin, PCBS	2008	TDEC
SFHOL007.7SU	South Fork Holston River	D/S Ft. Patrick Henry Dam	Metals, Organics, Dioxin, PCBS	1998	TDEC
SFHOL008.5SU	Ft. Patrick Henry Res/South Fork Holston Rv	Ft. Patrick Lake at Dam	Metals, Organics, PCBS	2006	TVA
SFHOL018.8SUB	Boone Res/South Fork Holston Rv	Dam	Metals, Organics, Dioxin PCBS	2006	TVA

Table 23: Fish Tissue Monitoring Stations (Continued)

STATION ID	RESERVOIR NAME/STREAM NAME	LOCATION	PARAMETER	LAST FY SAMPLED	SAMPLING AGENCY
SFHOL022.5SU	Boone Res/South Fork Holston Rv	Mouth of Wagner Creek	Metals, Organics, Dioxin, PCBS	2007	TDEC
SFHOL027.0SU	Boone Res/South Fork Holston Rv	South Holston Arm/ U/S Devault Road Bridge	Metals, Organics, Dioxin, PCBS	2006	TVA
SFHOL050.0SU	South Fork Holston	South Holston Lake Dam	Metals	2009	TVA
SFHOL062.7SU	South Fork Holston	TN/VA line over South Holston Lake	Metals, Organics, PCBS	2009	TVA
TENNE085.0HU	Kentucky/Tennessee Rv	D/S Turkey Creek (and transition QA)	Metals, Organics, PCBS	2008	TVA
TENNE097.0HU	Kentucky/Tennessee Rv	D/S Dupont-Johnsonville Plant	Metals, Organics, Dioxin, PCBS	2008	TDEC
TENNE200.0HD	Kentucky/Tennessee Rv	Near Hamburg (and Inflow QA)	Metals, Organics, PCBS	2008	TVA
TENNE417.1MI	Guntersville/Tennessee Rv	South Pittsburg Waterworks Intake	Metal, Organics, PCBS	1992	TDEC
TENNE425.5MI	Nickajack Res/Tennessee Rv	Near dam	Metals, Organics, PCBS	2008	TVA
TENNE457.2HM	Nickajack Res/Tennessee Rv	D/S Moccasin Bend WWTP	Metals, Organics, Dioxin, PCBS	2004	TVA
TENNE469.0HM	Nickajack Res/Tennessee Rv	Tailwater	Metals, Organics, PCBS	2008	TVA
TENNE472.3HM	Chickamauga Res/Tennessee Rv	Chickamauga Forebay near lighted buoy	Metals, Organics, Dioxin, PCBS	2008	TVA
TENNE489.8HM	Chickamauga Res/Tennessee Rv	Opossum Ck Light	Metals, Organics, PCBS	2008	TVA
TENNE518.0ME	Chickamauga Res/Tennessee Rv	Hwy 30	Metals, Organics, PCBS	2008	TVA

Table 23: Fish Tissue Monitoring Stations (Continued)

STATION ID	RESERVOIR NAME/STREAM NAME	LOCATION	PARAMETER	LAST FY SAMPLED	SAMPLING AGENCY
TENNE529.5HM	Chickamauga Res/Tennessee Rv	Below Watts Bar Dam	Metals, Organics, PCBS	2003	TVA
TENNE531.0RH	Watts Bar Res/Tennessee Rv	Near dam	Metals, Organics, PCBS	2009	DOE-O
TENNE560.8RO	Watts Bar Res/Tennessee Rv	Near Bullet Branch	Metals, Organics, PCBS	2009	DOE-O
TENNE600.0LO	Watts Bar Res/Tennessee Rv	D/S/ Ft. Loudon/Tellico Reservoirs near Lenoir City	Metals, Organics, Dioxin, PCBS	2008	DOE-O
TENNE602.0LO	Watts Bar Res/Tennessee Rv	Ft. Loudon dam tailrace	Metals, Organics, PCBS	2007	TWRA
TENNE604.0LO	Ft. Loudoun Res/Tennessee Rv	Forebay	Metals, Organics	2006	TVA
TENNE624.6KN	Ft. Loudoun Res/Tennessee Rv	D/S Lackey Creek near Lakeview	Metals, Organics, PCBS	2007	TVA
TENNE643.3KN	Ft. Loudoun Res/Tennessee Rv	Marine Base	Metals, Organics, Dioxin, PCBS	1999	TDEC
TENNE652.0KN	Ft. Loudoun Res/Tennessee Rv	D/s Confluence French Broad River	Metals, Organics, PCBS	2006	TVA
WATAU003.0SU	Boone Res/Watauga Rv	Watuaga arm near Deerlick Bend	Metals, Organics, Dioxin, PCBS	2007	TDEC
WATAU006.0SUB	Boone Res/Watauga Rv	Watauga Rv Arm At Pickens Bridge	Metals, Organics, PCBs	2006	TVA
WATAU036.6CT	Watauga Rv	Watauga Lake at dam	Metals	2009	TVA
WATAU045.6JO	Watauga Rv	Near Elk River Embayment	Metals, Organics, PCBS	2009	TVA
WOLF000.5SH	Wolf Rv	North Plant Pipe crossing	Organics, PCBS	1992	TDEC

Table 23: Fish Tissue Monitoring Stations (Continued)

STATION ID	RESERVOIR NAME/STREAM NAME	LOCATION	PARAMETER	LAST FY SAMPLED	SAMPLING AGENCY
WOLF001.5SH	Wolf Rv	Hwy 51	Metals, Organics, Dioxin, PCBS	2007	TWRA
WOLF009.3SH	Wolf Rv	Hwy 14	Metals, Organics, Dioxin, PCBS	1998	TWRA
WOLF015.3SH	Wolf Rv	Walnut Grove Road	Organics	1992	TDEC

Table 24: Parameters For Fish Tissue Analysis

Parameter
Weight (Pounds)
Length (Inches)
Lipid Content (Percent)
PCBs
Aldrin
Dieldrin
DDT, total
O, P - DDE
P, P - DDE
O, P - DDD
P, P - DDD
O, P - DDT
P, P - DDT
Endrin
Methoxychlor
Dioxins

Parameter
Chlordane, total
CIS Chlordane
Trans Chlordane
CIS Nonachlor
Trans Nonachlor
Alpha BHC
Gamma BHC
Hexachlorobenzene
Arsenic
Cadmium
Chromium
Copper
Mercury
Selenium
Lead
Zinc
Furans

B1.5 Laboratory Schedules

All chemical and bacteriological samples are delivered to the TDH Central or Regional Environmental Laboratory within holding time (Appendix D) for processing and analyses. SQSH samples are delivered to the TDH Nashville Environmental Laboratory, Aquatic Biology Section or processed by the EFO (if appropriate analyses, QC, and reporting protocols are followed). Periphyton samples are delivered to the TDH Nashville Environmental Laboratory, Aquatic Biology Section

TDH Environmental Laboratories accepts samples between 8 am and 4:30 pm Monday through Friday with the following exceptions:

- Bacteriological samples are to be delivered by 2:30 pm, unless prior arrangements have been made for later delivery.
- Bacteriological samples are not accepted on Fridays.
- 5-day BOD samples are not accepted on Mondays.
- 5-day CBOD samples are not accepted on Mondays.

The laboratory is contacted if samples cannot be delivered during normal business hours. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) provides TDH Environmental Laboratories contact information.

B1.6 Sampling Priority Schedule (Table 25)

Table 25: Project Activity Schedule

Project	**Type of Monitoring**	**Sampling frequency**	**Matrices**
Antidegradation	Biological*** (SQSH or Biorecon)	Once, if not on High Quality waters list for another reason or if biologist determines physical conditions would not support a diverse biological community	Benthics
TMDL development monitoring	Chemical and/or bacteriological*	Monthly*	Water column
Ecoregion reference stream monitoring	Chemical and bacteriological**	Quarterly**	Water column
	Biological*** (Biorecon and SQSH)	Spring and Fall***	Benthics
	Periphyton****	Annually	Periphyton
303(d) monitoring†	Chemical and/or bacteriological**	Monthly and or 5 E.coli/30days (preferably both) (See Table 21)	Water column
	Biological***(SQSH or Biorecon)	Once (Not required if pathogens are the only impairment.)	Benthics

Table 25: Project Activity Schedule (Continued)

Project	Type of Monitoring	Sampling frequency	Matrices
Watershed monitoring	Biological***(SQSH or Biorecon)	Once	Benthics
	Bacteriological**	Monthly and or 5 E.coli/30days (preferably both)	Water column
	Chemical**	Once (optional)	Water column
Fish tissue monitoring	Fish tissue	As needed	Fish tissue

*Consult *Monitoring to Support TMDL Development* (TDEC, 2001) for specifics.
**Consult the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) for specifics.
***Consult the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) for specifics.
****Consult the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) for specifics
†Consult the most recent 303(d) List approved by EPA.

B1.7 Rationale for the Sampling Design

The WPC water quality monitoring program measures Tennessee's progress toward meeting the goals established in the Federal Clean Water Act and the Tennessee Water Quality Control Act. Data are collected and interpreted in order to:

1. Assess the condition of the state's waters.
2. Identify stream segment/waterbodies with contamination that exceed Tennessee numerical or narrative water quality standards.
3. Identify causes and sources of water quality problems.
4. Document areas with potential human health threats due to fish tissue contamination or elevated bacteria levels.
5. Establish trends in water quality.
6. Document baseline stream conditions prior to a potential impact or identify a reference stream for downstream or other sites within the same ecoregion and/or watershed.
7. Measure water quality improvements resulting from site remediation, Best Management Practices, and other restoration strategies.
8. Identify proper waterbodies-use classification.
9. Evaluate waterbody tier for antidegradation implementation.
10. Identify natural reference conditions on an ecoregion basis for refinement of water quality standards.
11. Identify and protect wetlands.

B1.8 Parameter Selection

Table 8 lists analytes of interest for sampling objectives. Appendix D contains minimum detection limits, analytical method number, sample container requirements, sample preservation requirements, sample volume requirements and holding time information. QC requirements are listed in Section B5 and Table 37. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) provides additional chemical and bacteriological parameter selection information. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describes the method used to select the proper biological sampling approach.

B1.9 Procedures for Locating and Selecting Environmental Samples

Site selection is dependent on the study objectives. After determining the specific objectives of the study and clearly defining information need, sampling sites are identified within specific waterbody reaches. Reconnaissance of the waterway is very important. Possible sources of pollution, access points, substrate types, flow characteristics, and other physical characteristics are considered in selecting the sampling sites. Although the number and location of sampling stations vary with each individual study, the following basic rules are applied:

1. For **watershed screenings**, sites are located near the mouth of each tributary if representative of the stream as a whole. If impairment is observed, the watershed is inspected to see if the impairment is consistent. Additional monitoring is not needed if the impairment is consistent. However, if the impairment originates in a particular area, additional monitoring, if time allows, will help pinpoint the extent of the impairment.

2. For monitoring **point source** pollution, stations are located both upstream and downstream (below the mixing zone) of the source of pollution. Unless the waterbody is extremely small or turbulent, an effluent discharge will usually flow parallel to the bank with limited lateral mixing for some distance. If complete mixing of the discharge does not occur immediately, left bank, mid-channel and right bank stations may be established to determine the extent of possible impact. Stations are established at various distances downstream from the discharge. Collection stations are spaced farther apart going downstream from the pollution source to determine the extent of the recovery zone.

3. All biological sampling stations under comparison during a study shall have similar habitat unless the object of the study is to determine the effects of habitat degradation.

4. For biological surveys, it shall be determined if the study site can be compared to biocriteria or biorecon guidelines derived from the ecoregion reference database. To compare to biocriteria, the watershed upstream of the test site must be:

    a. At least 80% within the specified bioregion
    b. The appropriate stream order (estimated using topographic maps) or drainage area (GIS)
    c. Samples shall be collected using the method designated for that bioregion (SQKICK or SQBANK).

    If comparisons to biocriteria are inappropriate due to any of the above reasons, then an upstream or watershed reference site may be needed. Departure from protocols shall be explained in detail.

5. Sampling stations should be located in areas where the benthic community is not influenced by atypical conditions, such as those created by bridges or dams, unless judging the effects of atypical conditions is a component of the study objectives.

Sampling stations for macroinvertebrates shall be located within the same reach (200 meters or yards) where sampling for chemical and physical parameters will be located. If the macroinvertebrates are collected more than 200 meters from the chemical sampling, it is considered a separate station and assigned a different station ID number. Unless there are no tribs, dischargers or bank disturbance or other factors that would influence water quality.

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) has additional information on selecting biological sampling locations and the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) for information on selecting chemical stations. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) has additional information on selecting periphyton sampling locations. A list of stations including type and frequency is included in the monitoring program plan for each fiscal year beginning in July.

Inaccessibility

If a planned sampling location becomes inaccessible due to flooding, closed roads, or other temporary setbacks, if possible, sampling is rescheduled during normal flow and the sampling location is accessible. If a site is permanently inaccessible, the sampling location is moved upstream or downstream to nearest accessible location.

B1.10 Classification of Measurements as Critical or Noncritical

B1.10.a Biological Measurements

1. **Critical Biological** - Two biological monitoring types represent the primary biological indicators in Tennessee. The state relies heavily on biological monitoring to assess fish and aquatic life use support.

   a. Semi-Quantitative Single Habitat samples are used for stream tier evaluations (Antidegradation policy), permit compliance and enforcement, and as reference stream monitoring to refine biocriteria guidelines. Additionally, ambiguous biorecon sample results can be resolved by use of SQSH results.

      Biocriteria based on multi-metric indices composed of seven biometrics have been calculated and provide guidelines for each bioregion (Arnwine and Denton, 2001). The seven indices are:

      - Taxa Richness
      - EPT Richness
      - EPT Density
      - North Carolina Biotic Index
      - Density of Oligochaetes and Chironomids
      - Density of Clingers
      - Density of Nutrient Tolerant Taxa

   b. Biorecon samples are used for routine watershed assessments. Biorecon sampling events have been completed at reference streams to refine guidelines. At test streams, multi-metric indexes comprised of three descriptive biometrics are calculated and compared to reference guidelines for the bioregion. The three biometrics are:

      - Taxa Richness
      - EPT Richness
      - Intolerant Taxa Richness

2. **Noncritical Biological**
   - Fish IBI
   - Periphyton density
   - Chlorophyll *a*

B1.10.b Habitat/Physical Measurements

1. **Critical Habitat Measurements -** Habitat assessments using a process developed by Barbour et al. (1999) are conducted in conjunction with all biological monitoring and some chemical monitoring. Habitat guidelines based on reference conditions have been developed for wadeable streams in each ecoregion (Arnwine and Denton, 2001). The division has found these especially useful in assessing impairment due to riparian loss, erosion and sedimentation. The *QSSOP for Macroinvertebrate Steam Surveys* (TDEC, 2006) defines regional expectations for each of the parameters addressed in the assessment.

    - Epifaunal Substrate/Available Cover
    - Embeddedness
    - Pool Substrate Characterization
    - Velocity Depth Combinations
    - Pool Variability
    - Sediment Deposition
    - Channel Flow Status
    - Channel Alteration
    - Frequency of Riffles or Bends
    - Channel Sinuosity
    - Bank Stability
    - Bank Vegetative Protection
    - Riparian Vegetative Zone Width
    - Canopy Cover (Densiometer)

2. **Noncritical Physical/Habitat Measurements**

    - Stream Profile
    - Particle Count
    - Flow

B1.10.c Chemical/Toxicological Analyses

Chemical sampling is dependent on the monitoring needs (Table 26). Minimally, the following samples and field readings are taken:

1. **TMDL:** Monitoring to support pollutant-specific TMDL development depends on the TMDL type.

    a. **Metal TMDLs** (Minimum number of data points at each site is 12, some data points are obtained at low flow conditions).

- Critical: Flow, Hardness as $CaCO_3$, TSS, TOC, Metal(s) on 303(d) List, Selenium, pH, temperature, Specific conductance, and DO.
- Noncritical: Dissolved Metals (Cd, Cu, Pb, Ni, Ag, Zn).

b. pH TMDL (Minimum number of data points at each site is 12, some data points are obtained at low flow conditions).

- Critical: Acidity, Alkalinity, Flow, Hardness as $CaCO_3$, TSS, TOC, pH, temperature, Specific conductance, and DO.

c. DO TMDLs (Minimum number of data points at each site is 12, some data points are obtained at low flow conditions).

- Critical: Flow, pH, temperature (water), Specific conductance, DO, diurnal DO, $CBOD_u$ and $CBOD_5$, Ammonia, Nitrate/Nitrite, Total Phosphorus, Total Kjeldahl Nitrogen, and channel cross-section (transect profile, width, and depth).
- Noncritical: Velocity (dye study), temperature (air), CBOD decay rate, reaeration rate, SOD, chlorophyll *a*, field notes (weather conditions, presence of algae, point source discharge, etc.).

d. Nutrient TMDLs (Minimum of 12 monthly samples, minimum of four high-flow samples).

- Critical: Flow, Ammonia, Nitrate/Nitrite, Total Phosphorus, Orthophosphate, Total Kjeldahl Nitrogen, TSS, TOC, Turbidity, periphyton, chlorophyll *a*, pH, temperature, Specific conductance, DO, and Diurnal DO.
- Noncritical: Project specific and weather conditions.

e. Pathogen TMDLs (Minimum of 12 monthly samples, minimum of four high-flow samples)

- Critical: Fecal coliform, *E. coli*, TSS, Turbidity, pH, temperature, Specific conductance, and DO, Flow recommended if time allows (measured at wadeable streams, estimated at large rivers)
- Noncritical: weather conditions.

Table 26: Critical/Noncritical Activities for TMDL Development

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Metals TMDL		
Flow	X	
Water Field Parameters • pH • Temperature • Specific conductance • DO	 X X X X	
Chemical Parameters • Hardness, as $CaCO_3$ • TSS • TOC • Metal(s) on 303(d) List and Selenium	 X X X X	
Dissolved Metals (Cd, Cu, Pb, Ni, Ag, Zn)		X
pH TMDL		
Flow	X	
Water Field Parameters • pH • Temperature • Specific conductance • DO	 X X X X	
Chemical Parameters • Acidity, Total • Alkalinity, as Ca CO_3 • TSS • Hardness ($CaCO_3$) • TOC	 X X X X X	
DO TMDL		
Water Field Parameters • DO • Temperature • Specific conductance • pH • Diurnal DO	 X X X X X (minimum 2-weeks during growing season)	
Flow	X	
Velocity (Dye Study)		X
Channel Cross-section (transect profile)	X	
Air Temperature		X

Table 26: Critical/Noncritical Activities for TMDL Development (Continued)

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Chemical Parameters		
• $CBOD_5$ & $CBOD_{ultimate}$	X	
• NH_3	X	
• NO_2/NO_3	X	
• Total Phosphorus	X	
• TKN	X	
• CBOD decay rate		X
• Reaeration rate		X
• SOD		X
• Chlorophyll *a*		X
Nutrient TMDL		
Flow	X	
Field Parameters		
• Temperature	X	
• Specific conductance	X	
• pH	X	
• DO	X	
• Diurnal DO	X (minimum 2-weeks during growing season)	
Chemical Parameters		
• NH_3	X	
• $NO_2 + NO_3$	X	
• Total Phosphorus	X	
• Orthophosphate	X	
• TKN	X	
• TSS	X	
• TOC	X	
• Turbidity	X	
• Periphyton density (wadeable)	X	
• Chlorophyll *a* (non-wadeable)	X	
Pathogen TMDL		
Field Parameters		
• Temperature	X	
• Specific conductance	X	
• pH	X	
• DO	X	
• Flow	X Recommended if time allows (measured at wadeable streams, estimated at large rivers per Sherry Wang 4/3/09)	
Bacteriological Parameters		
• Fecal coliform	X	
• *E. coli*	X	
Chemical Parameters		
• TSS	X	
• Turbidity	X	

2. **Ecoregion Reference Stream:** The same critical parameters are collected at all ecoregion reference sites (Table 27). Specific chemical and bacteriological analyses are found in Table 8.

Table 27: Critical/Noncritical Activities for Ecoregion Reference Monitoring

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Chemical and bacteriological	X (Table 8)	
Flow	X	
Field Parameters • Temperature • Specific conductance • pH • DO	 X X X X	
Biorecon	X	
SQSH	X	
Habitat Assessment	X	
Channel cross section		X
Particle count		X
Fish IBI		X
Periphyton	X	
Chlorophyll *a*		X

3. **303(d) List:** Samples collected due to 303(d) listing are analyzed, at a minimum, for the pollutant(s) (cause) on the 303(d) List. 303(d) listed waters may be monitored for other parameters as needed (Table 28).

Table 28: Critical/Noncritical Activities for 303(d) Monitoring

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Chemical and/or bacteriological impairment cause on 303(d) List	X	
Other chemical and/or bacteriological parameters		X
SQSH *	X	
Habitat Assessment*	X	
Field Parameters • Temperature • Specific conductance • pH • DO	 X X X X	
Biorecon*		X
Periphyton		X

*Not required if pathogens are the only impairment.

4. **Long Term Trend Stations:** Samples from long term trend stations are minimally analyzed for the parameters listed in Table 8. Additional monitoring is not usually conducted at these long term sites. Any other monitoring is considered supplemental. The divisions monitoring program plan (TDEC, 2009) lists long term trend stations.

5. **Routine Watershed Screenings:** For routine watershed sampling, minimally, a biorecon sample is collected and field parameters (temperature, Specific conductance, pH, and DO) are measured to determine if waters support fish and aquatic life (Table 29). Bacteriological samples are collected to evaluate waters for recreational uses. Additional chemical monitoring may be conducted as needed. Table 8 lists recommended parameters.

Table 29: Critical/Noncritical Activities for Watershed Screening

MEASUREMENT TYPE	CRITICAL	NONCRITICAL
Biorecon	X*	
Field Parameters • Temperature • Specific conductance • pH • DO	 X X X X	
Habitat Assessment	X	
SQSH		X
Bacteriological	X	
Chemical	X (Table 8)	
Periphyton		X

*Collect SQSH macroinvertebrate sample if biorecon score is ambiguous.

B1.11 Sources of Variability

B1.11.a Chemical and Bacteriological Sample Variability

To check for variability in chemical and bacteriological samples**,** trip blanks, field blanks, equipment blanks, and duplicate quality control samples are collected at 10 percent of the sampling events. The *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2009) provides sample collection quality control additional information. When discrepancies from analyses of the samples are found, both the collection team and laboratory are contacted to determine the source of the contamination. Once the source of contamination is located, corrective actions are taken to avoid repeating these errors in the future. The *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004) has information regarding laboratory instrument blanks, analyses infrastructure, and corrective action procedures.

B1.11.b Biological Sample Variability

To check for variability in biological samples, duplicate biorecon, SQSH, or periphyton samples are collected at 10 percent of the sampling events. A second sampler collects duplicate biorecon samples and results are compared. If the samples generate differing results, the reasons for variability are determined and staff are retrained if necessary. In addition to collecting duplicate SQSH samples, 10 percent of processed samples are checked for sorting efficiency and taxonomic identification by a second experienced biologist. Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) provides additional sample variability information and corrective action measures. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides additional sample variability information and corrective action measures.

B1.11.c Field Parameter Variability

Minimally, duplicate field parameter readings are taken at the first and last sites surveyed each day. If time allows, duplicate readings are also recorded at each site to check for variability. Pre calibration and post drift checks are also required daily to help insure the field equipment is functioning correctly.

In the event measurements do not meet quality control guidelines, the field equipment is examined to determine the source of the problem and repaired or serviced as needed. Protocol J of the *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2009) or Protocol C of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) has specific quality assurance guidelines on field parameter meters. Protocol D of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) has specific quality assurance guidelines on field parameter meters.

B1.11.d Water Level Variability

In the event of flood or high water episodes, sampler safety is of paramount importance. Unless the sample is needed for TMDL development, sampling during flood events (when water is out of banks) should be avoided. If sampling during a flood event cannot be avoided, it is noted on associated paperwork and remarks section of Chain of Custody that the sample was collected during a rain or flood event, so the results can be evaluated accordingly. Field staff notify PAS so data are flagged with an R in the Water Quality Database.

Chemical and bacteriological samples are not collected if the stream only has water in isolated pools. Biological samples are not collected if the water level is extremely low or it appears the waterbody has not had continuous flow for at least 30 days.

B2 SAMPLING METHODS REQUIREMENTS

The objective of surface water sampling is to obtain a representative sample that does not deteriorate or become contaminated before it is analyzed. The proper sample collection, preservation techniques, and appropriate quality control measures must be followed to verify the accuracy and representativeness of sample analyses. This section describes the field procedures for collecting representative surface water samples.

B2.1 Sample Collection, Preparation, and Decontamination Procedures

Standard protocols have been established to meet the specific sampling requirements for the division's statewide monitoring program. Detailed procedures for chemical, bacteriological, and biological sample collection, preparation, and decontamination are in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). The reference documents for the division's monitoring program are listed in Table 30. The information provided in this QAPP supplements the SOPs for surface water sampling.

Table 30: Document Use

DOCUMENT TITLE	DESCRIPTION OF PROJECT ACTIVITY WHERE DOCUMENT IS USED
QSSOP for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2009)	• TMDL surveys • Reference stream monitoring • 303(d) listed monitoring • Watershed/305(b) monitoring • Long Term Trend Stations
QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2006)	• TMDL surveys • Reference stream monitoring • 303(d) listed monitoring • Watershed/305(b) monitoring

Table 30: Document Use (Continued)

DOCUMENT TITLE	DESCRIPTION OF PROJECT ACTIVITY WHERE DOCUMENT IS USED
QSSOP for Periphyton Stream Surveys (TDEC, 2010)	• TMDL surveys • Reference stream monitoring • 303(d) listed monitoring • Watershed/305(b) monitoring
Monitoring to support TMDL development (TDEC, 2001)	• TMDL surveys
Rules of the TDEC Division of WPC, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007)	• TMDL surveys • Reference stream monitoring • 303(d) listed monitoring • Watershed/305(b) monitoring
Rules of the TDEC Division of WPC, Chapter 1200-4-4, Use Classifications for Surface Waters (TDEC-WQCB, 2007)	• TMDL surveys • Reference stream monitoring • 303(d) listed monitoring • Watershed/305(b) monitoring
Tennessee Division of Water Pollution Control Monitoring and Assessment Program Plan (TDEC, 2009)	• TMDL surveys • Reference stream monitoring • 303(d) listed monitoring • Watershed/305(b) monitoring • Long Term Trend Stations
Final Version Year 2008 303(d) List (TDEC, 2008)	• 303(d) listed monitoring

B2.1.1 Sample Collection Procedures, Protocols, and Methods

- Chemical and bacteriological surface water samples are collected according to Protocols C through F in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009).

- *In situ* field parameters are measured according to Protocol J in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009).

- Continuous monitoring field parameters are measured according to Protocol K in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009).

- Composite, homogenized, and split samples are collected according to the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009).

- Flow is measured according to Protocol L in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009).

- Biorecon macroinvertebrate samples are collected according to Protocol F in the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006).

- SQSH macroinvertebrate samples are collected according to Protocol G in the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006).

- Periphyton samples are collected according to Protocols F and G in the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010)

- Fish tissue samples are collected according to the SOP *Fish Tissue Collection SOP No. Env-AqBio-SOP-512* (TDH, 2006).

Table 8 lists analytical requirements for different types of monitoring. Appendix D lists appropriate sample containers, preservatives volumes, and holding times for chemical and bacteriological surface water samples. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) provides additional information on sample collection and preservation.

B2.1.2 Sampling Equipment

Required equipment for chemical and bacteriological sampling are listed in Section I.H of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009). Equipment needed for biological sample collections are listed in Section I.H of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). A list of equipment is also found in Section A6.1.4 of this document. Equipment manual and logbooks kept in the EFOs list specific make, model, and serial numbers of sampling equipment.

B2.1.3 Support Facilities

Field water parameter meters and flow meters are calibrated at regional Environmental Field Offices. TDH Environmental Laboratories provide chemical, bacteriological, biological (SQSH), and periphyton laboratory analyses.

B2.1.4 Key Project Personnel (Table 31)

Table 31: Key Project Personnel

Name	Role
G. Wiggins	QAPP Project Manager
G. Denton	PAS WPC Manager
S. Wang	WMS WPC Manager
P. Patrick	JEFO WPC Manager
J. Holland	NEFO WPC Manager
J. Horton	JCEFO WPC Manager
T. Templeton	MEFO WPC Manager
R. Owens	CLEFO WPC Acting Manager
R. Urban	CHEFO WPC Manager
P. Schmierbach	KEFO WPC Manager
R. Howard	CKEFO WPC Manager

B2.1.5 Equipment Decontamination Procedures

When possible, all chemical and bacteriological samples are collected in the appropriate container. If an intermediate sampling device is used to collect a chemical sample, it shall be composed of Teflon® or High Density Polyethylene. All reusable sampling equipment is cleaned according to Protocol E of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009).

Bacteriological samples are collected directly into sterile sample containers. Subsurface bacteria samples may be collected in a sterile sampling container using a bottle holder connected to a long handle or rope. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) has additional information on bacteriological sampling procedures.

All nets used to collect macroinvertebrate samples are thoroughly rinsed to remove debris and clinging organisms after the sample is collected and before leaving the collection site. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) provides additional biological sample handling information.

B2.1.6 Sample Containers, Preparation, and Holding Time Requirements

Information provided in this QAPP supplements standard operating procedures established for these tasks. Section I.H of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) lists equipment and supplies needed for chemical and bacteriological sampling, flow measurement, and field parameter readings. Section I.H of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) lists equipment and supplies needed for biological sampling and field parameter readings.

Section I.H of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) lists equipment and supplies needed for biological sampling and field parameter readings.

Chemical and bacteriological sample containers obtained from the TDH Environmental Laboratories are certified-clean and pre-preserved. No additional preparation is needed. Appendix D lists sample containers, preservation requirements, and holding times for routine chemical and bacteriological samples. The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) provides additional information on sampling equipment, preservation, and holding times. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) provides information regarding macroinvertebrate sampling equipment and preservation. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides information regarding periphyton sampling equipment and preservation.

B2.3 System Failure and Corrective Action

B2.3.1 Sample Collection

a. If a sample cannot be collected as scheduled (flooding, dry, equipment failure, temporary inaccessibility, etc.) the EFO WPC manager or their designee is notified and the sampling event is rescheduled as soon as possible. If the site has become permanently inaccessible, it is moved upstream or downstream to the nearest accessible location. PAS is notified of the new station ID and location.

b. If ecoregion reference sites have become degraded, PAS is notified. If statistical analyses conducted by PAS indicate the site no longer meets reference criteria, the site is removed from the reference list for future sampling. Existing data will be maintained. The EFO is notified and is requested to select a replacement site in the same ecoregion.

c. If field equipment results are outside the calibration range during post drift check, results are flagged with N (uncertain of results). PAS is notified by email if results were already recorded on sample request sheet. If equipment becomes inoperable in the field, routine watershed monitoring continues without taking field measurements. If monitoring is for TMDL, ecoregion or 303(d) listed waters, sampling is rescheduled when properly functioning equipment is available.

d. If, when collecting SQSH samples, fewer than 200 organisms are estimated, additional samples of the same habitat are collected and composited. The total number of sampling efforts is noted on the Sample Analysis Form as well as internal and external tags.

e. Rain events are flagged with an R. (PAS flags results in the Water Quality Database.)

f. Additional issues are addressed in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010).

B2.3.2 Laboratory Analyses

a. **Biological:** If fewer than 160 organisms are found in a SQSH sample, the sample results are flagged and results are viewed with caution. The site is re-sampled if necessary to obtain acceptable results. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) has specific information regarding macroinvertebrate analyses.

b. **Chemical:** Any instrument that fails QC procedures shall not be used until the problem is corrected. Duplicate, laboratory fortified blank, laboratory fortified matrix, and method blanks that fail to meet goals are immediately reviewed for the source of error. Chemical analyses issues are addressed in the *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2002-2009), and the *Environmental Organic SOPs* (TDH, 2002-2009). Bacteriological analyses issues are addressed in the *Standard Methods for the Examination of Water and Wastewater* (APHA, 1995).

In the event that it is not possible to collect a sample, monitoring is rescheduled as soon as possible.

B2.4 QC Data Review

Results of field, trip, and equipment blanks are reviewed by PAS staff for potential contamination and the Quality Team Member (In-house QC officer in EFO). If contamination is found in the blanks, the collection and laboratory staff are contacted to determine and correct the source of contamination. All samples collected that day by the same team are viewed with caution, and excluded if outside of the existing data set.

Any analyses flagged by the TDH Environmental Laboratories are viewed with caution (Table 32) and excluded if outside of the existing data set. Samples collected during rain events are also flagged and viewed with caution.

Table 32: Data Qualifiers Key

Flag	Description
U	Analyte requested but not detected.
J	Estimated value-result is less than sample quantitation limit but greater than zero.
B	Analyte in blanks as well as sample.
E	Analyte concentration exceeds the calibration range of instrument.
N	Uncertainty in result other than "J" flag., a note – comment on the results sheet
Q	Received out of holding time.
Z	Analyzed out of holding time.
V	TDH Environmental Laboratories or EFO verified result.
R	Sample collected during rain event.
X	Other flag used to determine results as needed.

B2.5 Field Documentation

The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) stipulates field documentation for chemical, bacteriological samples, and flow measurements. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) stipulates documentation for macroinvertebrate surveys. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) stipulates documentation for periphyton surveys.

B2.6 Field Derived Waste

In most circumstances there is no field derived waste. In the event that waste is generated, it is contained until it can be properly disposed.

B2.7 Health And Safety

The *Health and Safety Plan* (TDEC-BOE, 2004) is followed for all procedures. Section I.D of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2008), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides additional health and safety warnings and cautions specific to water safety.

B3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

B3.1 Chemical and Bacteriological Handling Procedures

After chemical and bacteriological samples are collected, labeled, placed in a clean cooler on ice, and a custody seal is attached to the cooler, they are delivered to one of the TDH Environmental Laboratories. Usually samples are delivered in a state vehicle directly to the nearest TDH Environmental Laboratory by the sampling team. Occasionally, samples are transferred to another TDEC staff member or a commercial delivery service (courier

or bus service) for delivery to the TDH Laboratory. Chain of custody is completed each time a sample is transferred to another custodian.

"The use of custody seals may be waived if field investigators keep the samples in their custody as defined from the time of collection until the samples are delivered to the laboratory analyzing the samples." (*Ecological Assessment Standard Operating Procedures and Quality Assurance Manual.* USEPA Region 4, 2002).

Once samples are received in the TDH Environmental Laboratory, laboratory staff sign the chain of custody form and take custody of the samples. If samples are transferred to another laboratory, Laboratory Sample Control Log and Manifest and Interlaboratory Chain of Custody are completed.

A temperature blank is included in each cooler. Sample arrival temperature is checked in temperature blank bottles, to insure samples are 6^{o}C or less. This temperature is recorded on the Sample Analysis Form.

TDH Environmental Laboratories are secured facilities. Chemical samples are logged in and then stored in a central walk-in cooler until analyses. Bacteriological samples are processed immediately.

B3.2 Biological Sample Handling Procedure

After SQSH samples are collected, preserved, and labeled, they are delivered to TDH Environmental Laboratory, Aquatic Biology Section for processing. After receipt in the laboratory, SQSH samples are logged in, assigned a unique log number, and stored in the sample holding area until processed. Following analyses, macroinvertebrate samples are stored in a secured area for at least five years. The same logging and storage procedures are followed for SQSH samples processed by an EFO. Aquatic Biology is housed in TDH Central Laboratory in Nashville, which is a secured facility.

Biorecon samples are field processed and voucher specimens are confirmed in EFO laboratories. Biorecons are logged and assigned a unique log number (Table 33). The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) has additional information regarding biological sample handling procedures.

After periphyton samples are collected, preserved, and labeled, they are delivered to TDH Environmental Laboratory, Aquatic Biology Section for processing. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) has additional information regarding periphyton sample handling procedure. After receipt in the laboratory, periphyton samples are logged in, assigned a unique log number, and stored in the sample holding area until processed.

Table 33: Initial Letter Logging Abbreviations for Each Office

Abbreviation	Office	Abbreviation	Office
C	Chattanooga EFO (TDEC)	K	Knoxville EFO (TDEC)
L	Columbia EFO (TDEC)	M	Memphis EFO (TDEC)
V	Cookeville EFO (TDEC)	N	Nashville EFO (TDEC)
H	Johnson City EFO (TDEC)	S	Mining Section (TDEC)
J	Jackson EFO (TDEC)	B	Lab Services (TDH)

Copies of the field survey and habitat assessment sheets are sent to TDH Environmental Laboratory Aquatic Biology Section along with the SQSH samples. Copies of the biorecon results sheets are sent to WPC PAS. Copies of the rapid periphyton survey sheet, and habitat assessment sheets are sent to TDH along with the periphyton samples. After analyses and QC are completed, copies of bench sheets, analyses results, and all associated paperwork are sent to the EFO that collected the sample and PAS. If biological samples are processed in the EFO, copies of all paperwork and sampling results are sent to PAS.

Examples of field sample labels, Analysis Request and Chain of Custody Forms, and custody logs are included in the *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010)

The TDH Environmental Laboratories provide laboratory sample, handling, transport, and logging information in *Environmental - Receiving Samples Standard Operating Procedure – 101* (TDH, 2004), *Environmental – Sample Log-in Standard Operating Procedure – 102* (TDH, 2004), and *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004).

B3.3 Holding Times

Appendix D lists chemical and bacteriological sample holding times. Properly preserved biological samples have no specific holding time. Further information is provided in the *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010).

B3.4 Chain of Custody

TDEC's Office of General Counsel requires the chain of custody to be complete for any sample that has the potential for use in court, review by the Water Quality Control Board, or in state hearings. Therefore, all samples are potentially legal and the integrity of the

sample must be beyond question. The chain of custody form shall be completed in entirety and maintained in the project file.

The entire right column of TDH Environmental Laboratories' Chemical and Biological Analysis Request Form(s) is TDEC's official chain of custody. The TDEC Office of General Counsel has approved these forms. A copy of the chain of custody form for chemical analyses is in Appendix A of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009). A copy of the chain of custody form for biological analyses is in Appendix B of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006). A copy of the chain of custody form for periphyton analyses is in Appendix B of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). If using a TDEC contract laboratory other than TDH Environmental Laboratories, a separate chain of custody is completed.

The chain of custody follows the sample through collection, transfer, storage, analyses, quality assurance and disposal. Each person responsible for the sample signs, dates, and records the time when samples are transferred into their custody. The TDH Environmental Laboratories maintains a separate Sample Control Log and Manifest and Interlaboratory Chain of Custody for samples transferred between laboratories.

The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provide additional information on chain of custody. An interlaboratory chain of custody is completed when chemical samples are removed from the walk-in cooler for analyses. The *Environmental - Receiving Samples Standard Operating Procedure – 101* (TDH, 2004), the *Environmental – Sample Shipping Standard Operating Procedure – 104* (TDH, 2004), and the *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004) have additional sample transfer, handling, and analyses custody information.

B3.5 Sample Identification

The sampler identifies all chemical, bacteriological, and biological sample tags and associated paper work with the unique station identification number that has been assigned to the sample location. Protocol B in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describes the process for assigning station identification numbers.

Protocol H in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) provides additional information for completing and attaching external sample tag and labels for chemical and bacteriological samples. Protocols F and G in the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) provides information on internal and external tags for biological samples. Protocol G in the *QSSOP for*

Periphyton Stream Surveys (TDEC, 2010) provides information on internal and external tags for periphyton samples.

TDH Environmental Laboratories assign unique log numbers to each chemical and biological sample upon receipt for sample tracking. Both the station ID number and log number follow all paperwork associated with the samples.

The *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006), and the *Environmental - Receiving Samples Standard Operating Procedure – 101* (TDH, 2004) provide sample identification information. For macroinvertebrate samples processed in the EFO, a unique log number is assigned to each sample according to Protocol H in the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006). Protocol H of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describes the process for assigning log numbers for periphyton samples.

B3.6 Sample Custody Procedure: Summary of Standard Procedures

From the time of sample collection through analyses and sample disposal, custody of samples is documented via the chain of custody. A custody seal assures the sample integrity has not been compromised. Once chemical and bacteriological samples have been placed on ice, a signed and dated custody seal is attached to the cooler if the sample is transferred from the custody of the original sampler. The seal must be broken to open the cooler. If the seal is broken on receipt of the next custodian, the broken seal is documented.

Protocol I of Section 1 and Protocol C of Section II of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) provides chain of custody procedures for chemical and bacteriological sample collection. Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) addresses biological chain of custody procedures. Section II of the *QSSOP for Periphyton Stream Surveys* (TDEC, 200910) provides chain of custody procedures for periphyton sample collection.

B4 ANALYTICAL METHODS REQUIREMENTS

Valid and reliable analytical methods for the analyses of surface water samples are essential to yield precise, accurate, and comparable data. The division requires the use of approved EPA methods for all laboratory analyses. The reference documents for these methods are listed in Table 34. Analytical methods numbers and sensitivity requirements are found in Section B1.9

Table 34: Analytical Method Documents

Parameter	SOP Name
Macroinvertebrate	*QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006)*
Bacteriological	*Standard Methods for Examination of Water and Wastewater, 19th Edition* Section 9000 (APHA, 1995)*
Periphyton	*QSSOP for Periphyton Stream Surveys* (TDEC, 2010)*
Inorganic Chemistry	*TDH Environmental Inorganic SOPs* (TDH, 2002-2009)*†
Organic Chemistry	*TDH Environmental Organic SOPs* (TDH, 2002-2009)*†

*Regulatory citation: *The Tennessee Water Quality Control Act of 1977 including the 1998 amendments* (Tennessee Secretary of State, 1999).
†A complete list of Environmental Laboratory SOPs is included in the reference list.

B4.1 Analytical Methods and Method Sensitivity Requirements

The required analytical methods, minimum detection limits and reporting units are found in Table 35. Information on sample container, preservation, and holding times are found in Appendix D. The use of non-standard or unpublished methods, or deviations from the published EPA methods at Title 40 of the Code of Federal Regulations is not approved.

Table 35: Minimum Detection Limits, Reporting Units, and Analyses Methods**

Test	MDL	Units	Method*
Field Determinations			
pH		pH units	FIELD
Specific conductance		µmho	FIELD
Dissolved Oxygen		mg/l	FIELD
Temperature		Celsius	FIELD
Environmental Microbiology			
Total Coliform		CFU/100ml	SM9221B, 9223B
Test	**MDL**	**Units**	Method*
E. Coli		CFU/100ml	SM9221B, 9223B
Fecal Coliform		CFU/100ml	SM9221E, 9222D
Enterococcus		CFU/100ml	SM9230B/C

Table 35: Minimum Detection Limits, Reporting Units, and Analyses Methods** (Continued)

Test	MDL	Units	Method*
General Inorganics			
Acidity	NA	mg/l	SM2310B(4a)
Alkalinity, Total	10.0	mg/l	EPA 310.2
Boron	200.0	µg/l	SM4500B
BOD, 5 day	2.0	mg/l	SM5210B
CBOD, 5 day	2.0	mg/l	SM5210B
Chloride	1.0	mg/l	SM4500Cl-E/EPA 300.1
Chlorine, Residual	0.1	mg/l	SM4500Cl
Chromium, hexavalent	10	µg/l	SM3500-Cr B
Color, Apparent	5	Pt CO units	SM2120B
Color, True	5	Pt CO units	SM2120B
Specific conductance	1.0	µmhos	EPA 120.1
Cyanide (H_2O)		mg/l	SM4500CN-E
Fluoride	0.1	mg/l	SM4500F-B/EPA 300.1
Oil and Grease	5.0	mg/l	EPA 1664A
pH	NA	pH units	EPA 150.2
Phenols, Total	10.0	µg/l	EPA 420.1
Sulfate	3.0	mg/l	EPA 375.2/EPA 300.1
Residue, Dissolved	10	mg/l	SM2540D
Residue, Settleable	0.10	ml/l	SM2540F
Residue, Suspended	10	mg/l	SM2540C
Residue, Total	10	mg/l	SM2540B
Hardness, Total	10	mg/l	SM2340B
Silica	0.2	mg/l	SM4500-SiO2C
Turbidity	NA	NTU	EPA 180.1
Nutrients			
COD	5.0	mg/l	EPA 410.4
Nitrogen, Ammonia	0.03	mg/l	EPA 350.1
Nitrogen, Nitrite	0.005	mg/l	EPA 353.2/EPA 300.1
Nitrogen, Nitrate	0.007	mg/l	EPA 300.1
Nitrogen, NO_3 & NO_2	0.016	mg/l	EPA 353.2
Nitrogen, Total Kjeldahl	0.15	mg/l	EPA 351.2
Nitrogen, Total Organic	0.15	mg/l	EPA 351.2
Orthophosphate, Total	0.01	mg/l	EPA 365.1/EPA 300.1
Phosphorus, Total	0.02	mg/l	EPA 365.4
TOC	0.1	mg/l	SM5310C
Metals			
Aluminum	100.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111D
Antimony	3.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111B
Arsenic	1.0	µg/l	EPA 200.7, 200.8, 200.9
Barium	100.0	µg/l	EPA 200.7, 200.8/SM3111D
Beryllium	1.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111D

Table 35: Minimum Detection Limits, Reporting Units, and Analyses Methods (Continued)**

Test	MDL	Units	Method*
Cadmium	1.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111B or C
Calcium	2.0	mg/l	EPA 200.7/SM3111B
Chromium, Total	1.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111B or C
Cobalt	2.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111B or C
Copper	1.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111B or C
Iron	25.0	µg/l	EPA 200.7, 200.9/SM3111B or C
Lead	1.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111B or C
Magnesium	0.07	mg/l	EPA 200.7/SM3111B
Manganese	5.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111B
Mercury	0.029, 0.025	µg/l	EPA 245.1
Nickel	10.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111B or C
Potassium	0.3	mg/l	EPA 200.7/SM3111B
Selenium	2.0	µg/l	EPA 200.7, 200.8, 200.9
Silver	1.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111B or C
Sodium	0.15	mg/l	EPA 200.7/SM3111B
Thallium	2.0	µg/l	EPA 200.7, 200.8, 200.9/SM3111B
Vanadium	4.0	µg/l	EPA 200.7, 200.8/SM3111D
Zinc	4.0	µg/l	EPA 200.7, 200.8/SM3111B or C

***Environmental Inorganic SOPs* (TDH, 2002-2009) detail specific methods and required instrumentation.
**QC for laboratory analyses criteria is found in *Environmental Laboratories Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004).

B4.2 Equipment and Instrumentation

The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) lists equipment needed for macroinvertebrate analyses. The *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) lists equipment needed for periphyton analyses. The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009) provide detailed information about the type of equipment and instrumentation needed for chemical analyses. All equipment used in the field or in the lab must be calibrated,

maintained and repaired according to the equipment instruction manual. All instruments used by the lab must be calibrated, maintained, and repaired according to the specifications in the instrument instructions manual. Table 36 lists the methods requiring analytical instrumentation and the type of instrument used for detection of the specified analyte.

Table 36: Analytical Methods and Instrumentation*

Test	Method	Instrumentation
Environmental Microbiology		
Total Coliform	SM9221B, 9223B	NA
E. Coli	SM9221B, 9223B	NA
Fecal Coliform	SM9221E, 9222D	NA
Enterococcus	SM9230B/C	NA
Fecal Strep	SM9223B	NA
General Inorganics		
Acidity	SM2310B(4a)	pH Meter and Probe
Alkalinity	EPA 310.2	KoneLab Discrete Analyzer
Boron	SM4500B	KoneLab Discrete Analyzer
BOD, 5 day	SM5210B	Dissolved Oxygen Meter
CBOD, 5 day	SM5210B	Dissolved Oxygen Meter
Chloride	SM4500Cl-E/EPA 300.1	KoneLab Discrete Analyzer/IC
Chlorine, Residual	SM4500Cl	Spectrophotometer
Chromium, hexavalent	SM3500-Cr B	Spectrophotometer
Color, Apparent	SM2120B	KoneLab Discrete Analyzer
Color, True	SM2120B	KoneLab Discrete Analyzer
Specific conductance	EPA 120.1	Conductivity Meter
Cyanide	SM4500CN-E	KoneLab Discrete Analyzer
Fluoride	SM4500F-B/EPA 300.1	Ion Selective Electrode/IC
Nitrogen, Nitrite	EPA 353.2	Spectrophotometer/IC
Oil and Grease	EPA 1664A	NA
pH	EPA 150.2	pH Meter
Phenols, Total	EPA 420.1	KoneLab Discrete Analyzer
Sulfate	EPA 375.2	KoneLab Discrete Analyzer/IC
Residue, Dissolved	SM2540D	NA
Residue, Settleable	SM2540F	NA
Residue, Suspended	SM2540C	NA
Residue, Total	SM2540B	NA
Hardness, Total	SM2340B	NA
Silica	SM4500-SiO2C	Spectrophotometer
Turbidity	EPA 180.1	Turbidimeter
Nutrients		
COD	EPA 410.4	KoneLab Discrete Analyzer
Nitrogen, Ammonia	EPA 350.1	Flow Injection Analyzer
Nitrogen, Nitrate	EPA 300.1	Ion Chromatograph
Nitrogen, NO_3 & NO_2	EPA 353.2	Flow Injection Analyzer
Nitrogen, Total Kjeldahl	EPA 351.2	Flow Injection Analyzer
Nitrogen, Total Organic	EPA 351.2	Autoanalyzer
Orthophosphate, Total	EPA 365.1/EPA 300.1	KoneLab Discrete Analyzer/IC

Table 36: Analytical Methods and Instrumentation* (Continued)

Test	Method	Instrumentation
Phosphorus, Total	EPA 365.4	Flow Injection Analyzer
TOC	SM5310C	TOC Autoanalyzer
Metals		
Aluminum	EPA 200.7, 200.8, 200.9/SM3111D	ICP-OES, ICP-MS, GFAA/FAA
Antimony	EPA 200.7, 200.8, 200.9/SM3111B	ICP-OES, ICP-MS, GFAA/FAA
Arsenic	EPA 200.7, 200.8, 200.9	ICP-OES, ICP-MS, GFAA
Barium	EPA 200.7, 200.8/SM3111D	ICP-OES, ICP-MS/FAA
Beryllium	EPA 200.7, 200.8, 200.9/SM3111D	ICP-OES, ICP-MS, GFAA/FAA
Cadmium	EPA 200.7, 200.8, 200.9/SM3111B or C	ICP-OES, ICP-MS, GFAA/FAA
Calcium	EPA 200.7/SM3111B	ICP-OES/FAA
Chromium, Total	EPA 200.7, 200.8, 200.9/SM3111B or C	ICP-OES, ICP-MS, GFAA/FAA
Cobalt	EPA 200.7, 200.8, 200.9/SM3111B or C	ICP-OES, ICP-MS, GFAA/FAA
Copper	EPA 200.7, 200.8, 200.9/SM3111B or C	ICP-OES, ICP-MS, GFAA/FAA
Iron	EPA 200.7, 200.9/SM3111B or C	ICP-OES, GFAA/FAA
Lead	EPA 200.7, 200.8, 200.9/SM3111B or C	ICP-OES, ICP-MS, GFAA/FAA
Magnesium	EPA 200.7/SM3111B	ICP-OES/FAA
Manganese	EPA 200.7, 200.8, 200.9/SM3111B	ICP-OES, ICP-MS, GFAA/FAA
Mercury	EPA 245.1	FIMS (Flow Injection Mercury System)
Nickel	EPA 200.7, 200.8, 200.9/SM3111B or C	ICP-OES, ICP-MS, GFAA/FAA
Potassium	EPA 200.7/SM3111B	ICP-OES/FAA
Selenium	EPA 200.7, 200.8, 200.9	ICP-OES, ICP-MS, GFAA
Silver	EPA 200.7, 200.8, 200.9/SM3111B or C	ICP-OES, ICP-MS, GFAA/FAA
Sodium	EPA 200.7/SM3111B	ICP-OES/FAA
Thallium	EPA 200.7, 200.8, 200.9/SM3111B	ICP-OES, ICP-MS, GFAA/FAA
Vanadium	EPA 200.7, 200.8/SM3111D	ICP-OES, ICP-MS/FAA
Zinc	EPA 200.7, 200.8/SM3111B or C	ICP-OES, ICP-MS/FAA

*****_Environmental Inorganic SOPs_ (TDH, 2002-2009) detail specific methods and required instrumentation.

B4.3 TDH Environmental Laboratories Management (Table 37)

Table 37: TDH Environmental Laboratories Management

Name	Role
D. Smalley	Director of TDH Laboratory Services
R. Atkinson	Director of TDH KLAB
O. Walker	Director of TDH JLAB
B. Read	Director of TDH Environmental Laboratories
P. Singh	Assistant Director of Environmental Laboratories
J. Gibson	Director of TDH Microbiology Laboratories
T. Smith	Assistant Director of TDH Microbiological Laboratories
C. Edwards	Inorganic Chemistry Manager TDH NLB
S. Burchfield	Inorganic Chemistry Routines Supervisor TDH NLAB
A. Wilson	Inorganic Chemistry Metals Supervisor TDH NLAB
C. Ayers	Organic Chemistry Manager TDH NLAB
D. Maladas	Organic Chemistry Extractables Supervisor TDH NLAB
L. Maderal	Organic Chemistry Volatiles Supervisor TDH NLAB
P. Alicea	Aquatic Biology Manager TDH NLAB
R. Mitchell	Inorganic Chemistry Manager TDH JLAB
E. McCrary	Inorganic Chemistry Manager TDH KLAB
S. Staller	Inorganic Chemistry Supervisor TDH KLAB
C. LaFever	Quality Assurance Manager TDH Environmental Laboratories

B4.4 Laboratory Turnaround Time Requirements

Generally, Inorganic and Organic analyses should be sent by TDH Environmental Laboratories within 25 days of receipt of the sample. Microbiological samples should be sent to TDEC within 7 days of receipt of the sample. If results are not received in the expected time period, EFO staff contact the Environmental Laboratory section manager. Questionable results are referred by PAS staff to the appropriate TDH Environmental Laboratory or EFO. If possible, these issues are resolved within two weeks. Macroinvertebrate biological analyses turnaround is adjusted according to specific project deadlines. (If results are needed sooner than standard turnaround times, the needed priority date is recorded on the Analysis Request Form.)

B4.5 Laboratory Data Report

Chemical and bacteriological analysis reports and copy of chain of custody are mailed to the sampler and PAS for data management.

Biological result sheets are mailed to the sampler and PAS. The biological reporting package includes:

- Macroinvertebrate Assessment Report (SQSH only)
- Taxonomic List
- Biorecon Field Sheet (biorecon only)
- Habitat Assessment Sheets
- Stream Survey Sheets or Rapid Periphyton Survey Sheet
- Photographs (optional)
- Biological Analysis Request/Chain of Custody Form

B4.6 Sub-Sampling

Protocol I of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) describes sub-sampling procedures for SQSH samples. Protocol I of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describes sub-sampling procedures for periphyton samples. Subsampling protocols for chemical samples are provided in the *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009).

B4.7 Method Performance Criteria

The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009) have specific method performance criteria and failure policies for organic and inorganic analyses. Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) provides quality control, failure policies, and sorting criteria and taxonomic verification documentation procedures. Section II of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provides quality control, failure policies, and taxonomic verification documentation procedures.

B4.8 Sample Disposal Procedures

Macroinvertebrate samples are maintained at least five years after the sample is processed and identified. Since macroinvertebrate samples are preserved in 80% ethanol, they are considered hazardous waste and are disposed in accordance with MSDS. Since periphyton samples are preserved in formaldehyde, they are considered hazardous waste and are disposed in accordance with MSDS. The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009) provide various laboratory sample disposal procedures.

B4.9 Method Validation

Before adopting the *EPA Rapid Bioassessment Protocols for Use in Streams and Rivers* (Plafkin et al, 1989), SQSH samples were compared to Hester-Dendy and Surber samples and found to have comparable assessment results. Species saturation curves were completed at 100, 200, and 300 organisms. Two hundred organisms were found to provide the majority of taxa in most cases. When the 1999 revision of EPA's *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* was published (Barbour et al, 1999) single habitat samples were compared to multihabitat samples in 13 ecoregions with no significant difference in index results.

Chemical analyses results are validated by periodically comparing data systems results with manually calculated results and reviewing all data. The *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004) and the *Environmental Organic SOPs* (TDH, 2002-2009) provide method validation information. A complete list of TDH Environmental Standard Operating Procedures is included in the reference list. No non-standard or unpublished analyses methods are approved for 106 monitoring.

B4.10 Required Equipment and Reagents

The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009) describe required equipment and reagents.

B4.11 Corrective Action Process for Analytical System Failure

Any instrument failing QC standard is removed from service until the problem is corrected. Corrective action procedures for TDH Environmental Laboratories analyses are described in the *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, -2004) and the *Environmental Organic SOPs* (TDH, 2002-2009).

B4.12 Safety and Hazardous Material Disposal Requirements

All hazardous materials are handled and disposed of in accordance with MSDS requirements. The predominant hazardous materials used by field staff are calibration standards and ethyl alcohol. The *Environmental Inorganic SOPs (TDH, 2002-2009)* and the *Environmental Organic SOPs (TDH, 2002-2009)* describe handling and disposal protocols for chemicals used in sample analyses.

B5 QUALITY CONTROL REQUIREMENTS

Quality control is an integral part of Water Pollution Control's monitoring program. Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) stipulates quality assurance requirements, including duplicate samples, sorting efficiency, and taxonomic verification of macroinvertebrate sample collection, analyses and habitat assessment. Section II of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) contains quality assurance requirements for field, trip, and equipment blanks, duplicate, flow meters calibration, and field quality control measures. Section II of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) contains quality assurance requirements for field, trip, and equipment blanks, duplicate, flow meters calibration, and field quality control measures.

The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009) stipulate quality assurance requirements for chemical analyses including blanks, spikes, calibration check samples, and duplicates. Quality control requirements for microbiological analyses are outlined in Part 9000 of the *Standard Methods for Examination of Water and Wastewater*, 19th Edition (APHA, 1995).

B5.1 Quality Control Acceptance Criteria for Measurement Data (**Statistical Analyses)**

Data reduction procedures vary depending on:

- Type of data
- Number of data points
- Data distribution
- Purpose of data

Outlying data are generally included in the data set, unless they are considered atypical due to a flag (Table 32) or field notes. If it is determined that outlying data are atypical, the results are disregarded. Duplicate samples are averaged. Half of the detection limit is used for values below the detection limit. Analytical data associated with QC failures are not used. Data are tested for normality prior to statistical calculation. Procedures vary dependent on sample size (Table 38). Data are transformed prior to analyses if necessary. Generally, logarithmic or square root transformations are used.

Table 38: Tests Used to Determine Data Normality

Sample Size	Test
≤ 50	Shapiro Wilks
	Coefficient of Variation
> 50	Fillibens
	Skewness and Kurtosis
	Chi-Square
	Lillie for Kolmogorov-Sminoff
Any Size	Graphical

Applied statistical methods are used to summarize water quality data and make inferences from the data. Statistical methods are also used to determine the precision and bias/accuracy of the data. Basic statistical tests used to determine measures of relative standing, measures of central tendency, measures of dispersion, and measures of association are listed in Table 39.

Table 39: Tests Used for Statistical Analysis

Measure	Test
Relative Standing	Percentile
	Quantile
Central Tendency	Mean
	Median
	Mode
	Geomean
Dispersion	Range
	Variance
	Standard Deviation
	Coefficient of Variation
	Analysis of Variance
	Interquartile Range
Association	Pearson's Correlation Coefficient
	Spearman's Rank Correlation Coefficient
	Serial Correlation Coefficient
Trending	Mann-Kendall Test
	Partial Mann-Kendall Test

Graphical representations of the data are used to identify patterns and trends, confirm or disprove hypotheses, discover new phenomena, and identify potential problems. Graphs utilized to represent water quality data are listed in Table 40.

Table 40: Graphical Representations

Type of Data	Graph
Univariable Data	Histogram
	Frequency Plot
	Stem-and-Leaf Plot
	Box and Whisker Plot
	Ranked Data Plot
	Quantile Plot
	Normal Probability Plot
Multivariable Data	Profile Plot
	Glyph Plot
	Star Plot
	Scatter Plot
	Coded Scatter Plot
	Parallel Coordinate Plot
	Matrix Scatter Plot
	Empirical Quantile-Quantile Plot
Temporal Data	Time Plot
	Correlogram
Spatial Data	Posting Plot
	Symbol Plot
	H-scatter Plot
	Contour Plot

B5.2 Quality Control Checks and Procedures

Section II of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006), and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) describe field quality control procedures. QC activities are listed in Table 41.

The *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004) stipulates inorganic laboratory quality control procedures. Data precision and accuracy are described in Sections 10.1 and 10.2 of the *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004). Protocol M in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) and Part 9000 of the *Standard Methods for Examination of Water and Wastewater* (APHA, 1995) have QC procedures for bacteriological analyses.

B5.3 Quality Control for Fish Tissue Processing

Samples are generally composited, although large fish may be analyzed individually. Only fillets (including belly flap) are analyzed. Collection, filleting and packaging protocols follow the Aquatic Biology Section, TDH SOP as is agreed upon and reviewed by WPC. Analysis follows protocols found in *Fish Tissue Collection No.: Env-AqBio-SOP-512*, Revision 4. (TDH, 2006).

To check sample processing and analysis between labs, a round robin is performed on both processed and unprocessed samples between the TDH, TVA and ORNL labs. When funding permits, this is conducted annually. Results are used to target potential problems and refine techniques where needed.

If time and funding are available, one staff member from the Planning and Standards Section (WPC, TDEC) attends the National Forum on Contaminants in Fish annually. Information from this conference is used to refine protocols, enhance assessments, and gain knowledge of emerging contaminants.

Table 41: QC Activities

Activity	QC Requirement	Frequency	Desired Endpoint	Corrective Action
Biorecon Field Collection	Duplicate	10%	Same Index Range.	Determine reason for variability and retrain field staff if needed. Continue training and duplicate every sample until desired endpoint is consistently achieved.
Biorecon Field ID	Duplicate	10%	Same Index Range.	Arbitrate final ID and retrain if needed. Require retention of all specimens and QC all identifications until desired endpoint is consistently achieved.
Biorecon Field ID	Voucher Collection	New taxa	Office/lab voucher specimens for each site.	Correct field identification as necessary.
SQSH Field Collection	Duplicate	10%	Same Index Score.	Determine reason for variability and retrain field staff if needed. Continue training and duplicate every sample until desired endpoint is consistently achieved.
SQSH Sorting	Re-sort by 2nd taxonomist.	10%	90% sorting efficiency.	Re-sort all samples until desired endpoint is consistently achieved.
SQSH Identification	Re-ID by 2nd taxonomist.	10%	Pass chi-square at alpha 0.05.	Re-ID all samples until desired endpoint is consistently achieved.
SQSH Identification	Reference Collection	New taxa	Expert verification.	Correct initial lab identification as necessary.
SQSH Data Reduction	Re-calculate biometrics	10%	100% agreement.	Re-train and check 100% of calculations until desired endpoint is achieved.
SQSH Data Entry	Verify Data Entry	10%	100% agreement.	Check all data entry until desired endpoint is achieved.
Habitat Assessment	Completion of Habitat Assessment by Independent Assessor	10%	Same Final Assessment Category.	Arbitrate scores. Retrain if necessary. Continue training and continued 2nd independent assessment until desired endpoint is consistently achieved.

Table 41 QC Activities (Continued)

Activity	QC Requirement	Frequency	Desired Endpoint	Corrective Action
Rapid Periphyton Survey	Duplicate	10%	Same Index Range	Determine reason for variability and retrain field staff if needed. Continue training and duplicate every sample until desired endpoint is consistently achieved.
Multi-Habitat Periphyton Sample	Duplicate	10%	Same Index Range	Determine reason for variability and retrain field staff if needed. Continue training and duplicate every sample until desired endpoint is consistently achieved.
Multi-Habitat Periphyton Sample	Re-ID by 2nd taxonomist.	10%	Percent community similarity > 75%	Re-ID all samples until desired endpoint is consistently achieved.
Chemical and Bacteriological Collections	Trip Blank	10%	Less than detection limit.	Determine source of contamination (field or lab). Retrain or alter procedures depending on source. Flag data from samples collected on same trip (same parameter) and use data with caution.
Chemical and Bacteriological Collections	Field Blank	10%	Less than detection limit.	Determine source of contamination (field or lab). Retrain or alter procedures depending on source. Flag data from samples collected on same trip (same parameter) and use data with caution.
Chemical and Bacteriological Collections	Duplicates	10%	Within 20% of original sample.	Determine source of variability (natural, field contamination or analysis error). Re-sample, retrain, or alter procedures depending on source.
Chemical and Bacteriological Collections	Temperature Blank	Every cooler	Less than or equal to 6 degrees centigrade.	Flag results. Use data from samples in the same cooler with caution. Re-sample if necessary.

Table 41 QC Activities (Continued)

Activity	QC Requirement	Frequency	Desired Endpoint	Corrective Action
Chemical and Bacteriological collection using reusable equipment (buckets, bailers, automatic samplers etc.)	Equipment Field Blank	10%	Less than detection limit.	Determine source of contamination. Flag results use data from sample collected with questionable equipment with caution.
Instantaneous Field Parameters	Duplicate	Every site recommended (First and last each day required)	Within 0.2 units for pH, and temperature DO. (10% for DO measured in % saturation.) Within 10% of reading for Specific conductance.	Repeat procedure until reproducible results are achieved. If reproducible results are not achieved, discard data and repair probe.
Instantaneous Field Parameters	Calibration	Beginning and end of each sampling trip.	Pre-calibration, probe must be able to be adjusted to standards. Post calibration must be within 0.2 units for pH, DO and temperature and within 10% of reading for Specific conductance.	Pre-calibration, do not use probe if cannot be adjusted to standards. Repair, clean or change membranes as necessary. Post-calibration out of range, flag all measurement taken that trip, notify PAS by email if measurements already recorded on sample request sheets. Determine source of problem and remedy before meter is used again.
Continuous Field Parameters	Duplicate	10%	Measurements within 10%.	Determine source of discrepancy (probe placement, siltation, algal growth, malfunction, calibration drift etc.) Flag data and use with caution.
Flow Measurement	Duplicate	10%	Velocity within 10%.	Flag results, use with caution.
Chemical analyses blanks, spikes and duplicates.	TDH Environmental Lab SOP is specific for each parameter.	TDH Environmental Lab SOPs is specific for each parameter.	TDH Environmental Lab SOP is specific for each parameter.	TDH Environmental Laboratories SOPs are specific for each parameter. See references for a complete list. The *Environmental Laboratories Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004) details quality assurance procedures.

Table 41 QC Activities (Continued)

Activity	QC Requirement	Frequency	Desired Endpoint	Corrective Action
TDH Laboratories data precision	Duplicate samples	10%	Warning limits and control limits are calculated.	*Environmental Laboratories Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH 2004) has specific information.
TDH Laboratories data accuracy	• Lab fortified blanks • Lab fortified matrices	As needed	Measure analyses accuracy (precision + bias).	*Environmental Laboratories Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH 2004) has specific information.
TDH Laboratories method blanks	Method blank	As needed	Determine if activity is added to sample from reagent.	*Environmental Laboratories Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH 2004) has specific information.
TDH Laboratories data reduction	• Hand calculation • Excel program • Instrument readout	Every sample	Correct interpretation of analyses results.	*Environmental Laboratories Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH 2004) has specific information.
TDH Laboratories data validation	Computer calculation are checked against hand calculated results	Periodically	Confirm computer calculations are correct.	*Environmental Laboratories Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH 2004) has specific information.
E. coli analysis	Media reagent check	Each new lot	Compare to standards.	Do not use media lot.
E. coli analysis	Methods check	10%	Compare to expected results.	Flag results as questionable. Use with caution.
E. coli analysis	Sealer check	Monthly	Dye outside wells.	Replace sealer.

B6 INSTRUMENT AND EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

B6.1 Field Equipment

All field equipment and on site-testing equipment for chemical and bacteriological sampling are listed in Section I.H of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009). Field equipment required for macroinvertebrate sampling is described in Section I.H of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006). Field equipment required for periphyton sampling is described in Section I.H of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). The equipment lists are also located in section A6.1.4 of this document.

B6.2 Field Equipment and Instrument Testing, Inspection, Maintenance, Repair, and Criteria for Acceptability

Protocols G, J, K, and L of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) stipulates acceptance criteria, testing and maintenance procedures and documentation requirements for field instruments including composite samplers, field parameter meters and flow meters. All field equipment is inspected, calibrated and tested each day the equipment is used. Generally spare parts are not warehoused for field equipment. In the event of malfunction, equipment is immediately sent for repair or replacement if spare equipment is not available. It is the responsibility of the EFO manager and/or in-house QC officer to verify procedures are followed.

B6.3 Laboratory Equipment and Instrument Testing, Inspection, Maintenance, and Repair

All TDH Environmental Laboratories' instruments undergo regularly scheduled preventative maintenance either by the instrument manufacturer via service agreement or by laboratory personnel, as stipulated in the *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004). The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009) stipulate laboratory equipment and instrument acceptance criteria, testing criteria, inspection, maintenance and repair protocols and documentation procedures.

B6.4 Consumable Supplies

Buffer solutions, calibration standards, and required meter calibration are described in Protocol J of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), Protocol C of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and Protocol C of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). In each EFO, the In-house QC Officer is responsible for insuring the appropriate number of sample containers and other consumable supplies are available. The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-

2009) detail solvents, reagents, and buffer solutions used for sample analyses. TDH Environmental Laboratory Inventory Control Section is responsible for insuring appropriate amounts of solvents, reagents, buffer solutions, and other consumable supplies are available for analyses.

B7 INSTRUMENT CALIBRATION AND FREQUENCY

Protocols G, J, K, and L of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) describe calibration procedures and documentation for field instruments including composite samplers, field parameter meters and flow meters. All field equipment is calibrated minimally once a week, followed by post drift check.

Calibration records are documented in the appropriate bound calibration logbook. If instruments do not maintain calibration, the source of the problem is determined and resolved with maintenance. If the problem cannot be solved in-house, a repair authorization is requested. Any maintenance or repairs are documented in the appropriate instrument logbook.

B7.1 Field Instrumentation Calibration

Protocols J, K, and L of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) stipulate instrument calibration, calibration frequency, and documentation procedures for instantaneous field parameter meters, continuous monitoring field parameter meters, and flow meters. Protocol C of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and Protocol D of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) stipulate instrument calibration, calibration frequency, and documentation procedures for instantaneous field parameter meters. Logbook requirements, calibration acceptance criteria, calibration of standards and equipment, and documentation are also specified in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2008). Field meters used are the multi-parameter probe, flow meter, dissolved oxygen meter, conductivity meter, pH meter, temperature meter or thermometer in ^{o}C.

B7.2 Laboratory Instrumentation Calibration

According to the *Environmental Laboratories Inorganic Chemistry Laboratory Quality Assurance Plan* "all service calibration and maintenance records are kept in permanent logbooks and/or files" (TDH, 2004, p. 9). The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009) stipulate calibration acceptance criteria, calibration of standards and equipment, requirements, procedures, frequency, documentation, equipment certification, and protocols for repairing/recalibrating laboratory equipment.

B8 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

B8.1 Acceptance Criteria for Supplies and Consumables

Sections I.H of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009), the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) provide a list of supplies required for field sampling. These documents also outline acceptance requirements. The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009) stipulate supply acceptance criteria for chemical analyses. Managers in the Aquatic Biology, Inorganic and Organic TDH labs are responsible for insuring all supplies and consumables meet acceptance criteria. See B6.4 for requirements for solvents, reagent, buffer solution and other consumable supplies.

Necessary field equipment varies depending on the project and monitoring objectives. Table 42 is a standardized list of general field equipment.

Table 42: Acceptance Criteria for General Field Equipment

General Field Equipment	Acceptance Criteria
GPS Unit	Must be calibrated and capable of measuring lat and long to four decimal places
Dissolved Oxygen Meter	Must be calibrated and capable of measuring dissolved oxygen in % to one decimal place and in mg/L to two decimal places, range 0 to 20 mg/L, accuracy +/- 02mg/L
pH Meter	Must be calibrated and capable of measuring pH to one decimal place. Range 2 to 12 units, accuracy +/- 0.2 mg/L
Conductivity Meter	Must be calibrated and capable of measuring Specific conductance in uMhos/cm or S/m to four digits or one decimal place. Range 0 -100,000 uMhos/cm, accuracy +/- 1% of reading

Table 42: Acceptance Criteria for General Field Equipment (continued)

General Field Equipment	Acceptance Criteria
Thermometer	If thermometer used can be -calibrated and capable of measuring temperature in ºC to two decimal places. Range –5^{o}C to 45^{o}C. Accuracy +/- 0.20^{o}C
Flow Meter	Must be calibrated and capable of measuring flow in cfs to two decimal places
Wading Rod	Must be able to measure in feet to one decimal place
Surveyors or Measuring Tape	Must be capable of measuring in feet to one decimal place
Gloves	Must be powder-free latex or nitrile gloves (required for nutrient sampling) or shoulder length powder-free gloves (required for trace metals or mercury sampling)
Triangular Dip Net	Must be 500 micron mesh
Square Kick Net	Must be one meter square with 500 micron mesh
Rectangular Net	Must be 18” long with 500 micron mesh
Sample Bottles	Must be in accordance with QSSOPs for Chemical and Bacteriological Sampling and Macroinvertebrate Sampling as described in Section I.H of each QSSOP
Bacteriological Bottles	Must be sterile polypropylene, screw-cap 250mL bottles
Nutrient Bottles	Must be certified clean single use 500mL plastic bottles
Metal Bottles	Must be certified clean single use 1-L plastic bottles
Mercury Bottles	Must be certified clean single use 500mL plastic bottles
Cyanide Bottles	Must be certified clean single use 1-L plastic bottles
Sulfide Bottles	Must be pre-cleaned 500mL glass bottles
Boron Bottles	Must be pre-cleaned 125mL plastic bottles
TOC Bottles	Must be pre-cleaned 40mL glass vials

Table 42: Acceptance Criteria for General Field Equipment (Continued)

General Field Equipment	Acceptance Criteria
Base/Neutral/Acid Extractable Bottles	Must be pre-cleaned 1-gallon amber bottles with Teflon®-lined cap
Volatiles and Petroleum Hydrocarbons	Must be pre-cleaned 40-mL amber vials with Teflon®-lined septa cap
Extractable Petroleum Hydrocarbons	Must be pre-cleaned 1-gallon amber bottles with Teflon®-lined lid

Necessary laboratory equipment varies depending on the type of analysis performed. Table 43 is a standardized list of general laboratory equipment.

Table 43: Acceptance Criteria for General Laboratory Equipment

General Laboratory Equipment	Acceptance Criteria
Dissecting Microscope	Must have 10X, 15X, or 20X oculars with an objective 0.67-4.0 variable
Compound Microscope	Must have 10X ocular with objectives 100, 40, 10, and 3.2 variable
Balance	Must be verified and certified calibrated by a manufacturer certified technician and capable of measuring mass to four decimal places or method specified accuracy to be within ±1 in the final decimal place
Conductivity Meter	Must be calibrated and capable of measuring Specific conductance in uMhos or S/m to three digits or one decimal place
Thermometer	NIST traceable/certified thermometers or non-NIST thermometers that have been calibrated against NIST traceable/certified thermometer or calibrated infrared thermometer, must be capable of measuring in ºC to two decimal places
Incubator	Must have a NIST traceable/certified thermometer or calibrated thermometer and capable of measuring at 35ºC $\pm$ 0.5

Table 43: Acceptance Criteria for General Laboratory Equipment (Continued)

General Laboratory Equipment	Acceptance Criteria
Refrigerator	Must be capable of holding a constant temperature $\pm 1^{\circ}C$
Freezer	Must be capable of holding a constant temperature $\pm 1^{\circ}C$
Drying Oven	Must be capable of holding a constant temperature 65-210 $\pm 1^{\circ}C$
Autoclave	Must be verified sterilized and capable of reaching a maximum temperature of $121^{\circ}C$ or greater
Centrifuge	Must be capable of reaching a speed of at least 3000 rpm
Mechanical Volumetric Dispensing Devices	Must be checked for accuracy against Class A glassware

Major instrumentation includes items such as: Graphite Furnace Atomic Absorption Spectrophotometer (GFAA), Inductively Coupled Plasma Emission Spectrometer (ICP-AES), Gas Chromatogram (GC), Gas Chromatogram/Mass Spectrometer (GC/MS), and Konelab Automated Analyzer. All major instrumentation is maintained in accordance with manufacturer's recommendations and operational guidance. Table 44 is a list of major instrumentation used in the laboratory.

Table 44: Acceptance Criteria for Laboratory Instrumentation

Laboratory Instrumentation	Acceptance Criteria
Graphite Furnace Atomic Absorption Spectrophotometer (GFAA)	Must have Zeeman-effect background correction, transversely heated, graphite tubes, and gas supply. Light source must either be a hollow cathode lamp (HCL) or an electrodeless discharge lamp (EDL).
Inductively Coupled Plasma Emission Spectrometer (ICP-AES)	Must have background-correction capability, a radio-frequency generator, refrigerated recirculator, variable speed peristaltic pump, mass flow controllers, and gas supply. Light source must either be a hollow cathode lamp (HCL) or an electrodeless discharge lamp (EDL).

Table 44: Acceptance Criteria for Laboratory Instrumentation (Continued)

Inductively Coupled Plasma Mass Spectrometer (ICP-MS)	The spectrometer shall consist of an inductively coupled plasma ion source, a quadrupole mass filter, and an ion detection system. A micro computer system and necessary software shall be provided for instrument control and for data acquisition, reduction, presentation, and storage. The spectrometer system shall include all equipment necessary for the maintenance of high vacuum and the introduction of samples by conventional solution nebulization. All other equipment, special tools, and software necessary for the operation of the system in accordance with the requirements of this specification shall be provided. The function of the Inductively Coupled Plasma Mass Spectrometer (ICP-MS) System shall include the introduction, atomization, ionization and mass analysis of dissolved samples so the qualitative identification, quantitative composition and isotopic composition of the elemental constituents of the samples can be determined.

Table 44: Acceptance Criteria for Laboratory Instrumentation (Continued)

Laboratory Instrumentation	Acceptance Criteria
Gas Chromatograph/Flame Ionization Detector (GC/FID)	Must have a temperature programmable oven with a range 20 - 450ºC, gas supply, and able to operate with various columns and injectors as required by the method.
Gas Chromatograph/Electron Capture Detector (GC/ECD)	Must have a temperature programmable oven with a range –99 - 450ºC, gas supply, and able to operate with various columns and injectors as required by the method.
Gas Chromatograph/Nitrogen Phosphorus Detector (GC/NPD)	Must have a temperature programmable oven with a range –99 - 450ºC, gas supply, and able to operate with various columns and injectors as required by the method.
Gas Chromatograph/Mass Spectrometer (GC/MS)	Must have a temperature programmable oven with the appropriate temperature range as required by the method, have a gas supply, and able to operate with various columns and injectors as required by the method.
Automated Discreet Analyzers	Must be capable of detecting analytes at the appropriate wavelengths as required by the method.

Necessary laboratory supplies vary depending on the type of analysis performed. Table 45 is a standardized list of general laboratory supplies.

Table 45: Acceptance Criteria for Laboratory Supplies

Laboratory Supplies	Acceptance Criteria
Glassware	Must be high quality borosilicate glass
Volumetric Glassware	Must be Class “A” quality
Reagents, Chemicals, Solvents	Must be in accordance with purity criteria for specified method
Laboratory Quality Water	Must be in accordance with purity criteria for specified method
Deionized Water	Must be deionized by cation, anion, and mixed bed units in the laboratory and have a resistivity > 1 megaohm-cm @ 25ºC
Nanopure Water	Must be reagent grade water and have a resisitivity > 10 megaohm-cm @ 25ºC

B8.2 Inspection or Acceptance Testing Requirements and Procedures

The *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009) stipulate inspection or acceptance testing requirements and procedures. Managers in the Aquatic Biology, Inorganic and Organic TDH labs are responsible for insuring all supplies and consumables meet acceptance criteria.

B8.3 Tracking of Supplies and Consumables

The Inventory Control Section of TDH Laboratories purchases, tracks, receives, and stores supplies required for chemical, bacteriological, and biological analyses. The TDH Environmental Laboratories verifies the quality of each lot of sample bottles and reagents. As supplies are needed, they are ordered directly from Inventory Control. In each EFO, the WPC manager or their designee is responsible for ordering and inspecting supplies (Table 46).

Table 46: Inventory Inspectors

Name	Location
N. Sanders	TDH Environmental Laboratories - Inventory Supplies
P. Patrick	TDEC - WPC - JEFO
J. Holland	TDEC - WPC - NEFO
R. Howard	TDEC - WPC - CKEFO
J. Horton	TDEC - WPC - JCEFO
T. Templeton	TDEC - WPC - MEFO
R. Owens	TDEC - WPC - CLEFO
R. Urban	TDEC - WPC - CHEFO
P. Schmierbach	TDEC - WPC - KEFO

B9 DATA ACQUISITION REQUIREMENTS (NON-DIRECT MEASUREMENTS)

Acceptance Criteria

Non-direct measurement techniques are used to supplement measured data. The primary non-direct measurements are historical data in literature and visual assessments. Historical information is available infrequently and visual assessments are available sporadically. These data are never used alone for water quality assessments, but rather used for historical context or as a screening for further direct monitoring. These data are noted in the comment section of the ADB entry for the specific waterbody.

B10 DATA MANAGEMENT

B10.1 Purpose and Background

Due to the large amount of data collected in monitoring activities, it was paramount that the division developed an electronic database to store and easily retrieve data for analyses and assessment. Data from the early 1970s through 1999 were stored in what is now called Legacy STORET. In 1998 the division developed an Access database, called the Water Quality Database (WQDB), to store not only station location and chemical and bacteriological results, but also biorecon, SQSH, habitat assessment, and periphyton results. Quarterly, station location, chemical and bacteriological data were uploaded into the modernized USEPA STORET Database. In September 2009 EPA ceased support of the current format data is uploaded to STORET, as such the last upload of TDEC WPC data was sent to EPA the end of September 2009. The data can be located at STORET at http://www.epa.gov/STORET

B10.2 Record Keeping

Electronic records stored on the TDEC Central Office server are backed-up nightly on 22-cycle tape by TDEC Information Systems personnel. The WQDB is sent electronically monthly to each of the eight Environmental Field Offices and TDH Environmental Laboratories Aquatic Biology Section. Paper files are permanently stored for reference in the Planning and Standards Section (Table 17). TDH Environmental Laboratories' logs, instrument printouts, calibration records, and QC documents are stored at TDH Environmental Laboratories. All data records produced by TDH Environmental Organic Laboratories are stored on site for at least six years and then archived for 30 years.

B10.3 Data Recording

After the initial quality assurance checks are performed, PAS technical staff enter station identification information and chemical, bacteriological, macroinvertebrate, habitat, and periphyton data into the Water Quality Database (WQDB). Only PAS technical staff can enter data or change data results in the master WQDB housed on the Central Office server. A copy of the WQDB is sent monthly to EFO and CO personnel; however, these personnel do not have access to change the master WQDB.

B10.4 Standardized Forms

Copies of electronic data entry forms for the WQDB, SQDATA, and ADB are provided in Appendix E. Copies of the Environmental Field Office Monitoring Audit Report and data verification forms are provided in Appendix F.

B10.5 Data Quality Assurance Checks (Validation)

Chemical, bacteriological, macroinvertebrate, habitat, fish tissue, and periphyton analyses reports are reviewed by PAS technical staff for correct cost code, appropriate chain of custody, station identification number, and unusual parameter results. Only PAS technical staff enter the data into the WQDB. Data results checklists are completed for analyses results received for chemical results (Appendix F). Questionable results are referred to the TDH Environmental Laboratories or the collecting office for verification or correction. Quality assurance checks are performed on a minimum of 10 % of the data entered. A copy of the WQDB is sent monthly to the EFO staff for review for errors and additions.

B10.5.1 Computer Requirements for EQUIA Upload

- The data transfers to WQS will be using the node on the Environmental Exchange Network in Tennessee.

B10.5.2 Software Requirements for EQUIS Upload

- EARTHSOFT EQUIS Database
- Water Quality Database (WQDB)
- SQ Database
- ADB
- Excel 2000
- Access Database

B10.5.3 Software Requirements for Data Analysis

- EDAS – Ecological Data Application System
- Statview
- Excel - Poptools
- Multi –variant Statistical Package
- OS4 – OpenStat4
- MULTMK/PARTKMK – Multivariate and Partial Mann-Kendall Test

- GIS – Geographic Information System
- LIMS (Lab)

B10.6 Data Transformation

Currently TDEC WPC is working with EARTHSOFT to utilize the software EQUIS to upload data to the EPA WQX framework. The Water Quality Exchange (WQX) is a new framework that makes it easier for States, Tribes, and others to submit and share water quality monitoring data over the Internet.

B10.7 Data Transmittal

WPC staff collects chemical, bacteriological and biological samples across the state. The data are used for watershed assessments, ecoregion reference sampling and TMDL development. The QSSOP *for Macroinvertebrate Stream Surveys* (TDEC, 2006), the *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2009) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) are followed for sampling protocol. Samples are delivered to TDH Environmental Laboratory for analyses. The TDH Environmental Laboratories provide chemical and bacteriological analyses reports (paper copies) approximately 25 days after samples are collected. It may take as long as a year for biological samples to be analyzed depending on the project.

The analyses reports are sent to the appropriate EFO and PAS. PAS technical staff receives the data for review and entry into the WQDB. One technical staff member in PAS, Linda Cartwright (Biologist 3), oversees all water quality data management. The Water Quality Database is sent monthly to the Environmental Field Office (EFO) staff for review for errors and additions. After data are reviewed the data will be sent to EPA through EARTHSOFT's EQUIA software to EPA's WQX framework.

B10.8 Data Reduction

Environmental Laboratory data reduction is calculated manually using, Microsoft Excel or direct instrument readout. Data are used for a number of programs, including watershed assessments, ecoregion reference sampling and TMDL development. Queries are made from a read-only copy of the WQDB for the appropriate information by technical staff. Various statistical programs such as STATVIEW are used to test data. The original Access Water Quality Database is only accessed by a minimum number of staff to ensure the integrity of the database.

The Ecological Data Application System (EDAS) Database named SQDATA provides metrics used to calculate index scores for SQSH and periphyton samples. The index scores are compared to biocriteria. The Assessment Database (ADB) stores waterbody assessment information.

B10.9 Data Tracking

TDH Environmental Laboratories notify PAS and EFO staff when chemical, bacteriological, and biological analyses reports will be sent. If the reports are not received at PAS, TDH Environmental Laboratories are contacted to locate the missing analyses reports. Data are entered into the WQDB, after initial QA/QC. A unique station identification number (section B3.3) assigned to each sampling location is used to track all sampling activities at that station. TDH Environmental Laboratories assign a unique lab number (activity id number) to each sample. This lab number is entered into the WQDB and is the primary tool for tracking data.

The divisions program plan *(TDEC, 2009)* includes a list of all waterbodies to be sampled for the fiscal year. At the end of each quarter of the fiscal year, PAS and EFO staff reviews the program plan list, to insure that chemical and bacteriological analyses reports were received from TDH Environmental Laboratory Services for all stations sampled. TDH Environmental Laboratories are contacted if there are missing reports. The Aquatic Biology Section of TDH Environmental Laboratories sends electronic copies of the macroinvertebrate sample log quarterly. This log is reviewed by a PAS biologist to determine if results from completed samples have been received and to set analyses priorities and deadlines.

B10.10 Data Storage and Retrieval

Chemical, bacteriological, biological and habitat data are stored electronically in the WQDB and paper copies are in files in PAS. Benthic taxonomic lists for SQSH and periphyton samples are stored in an Ecological Data Application System (EDAS) Access database named SQDATA at the TDH Environmental Laboratory Aquatic Biology Section.

Backup copies of the WQDB are retained in PAS, at eight EFO offices, and on the TDEC server. The EDAS database (SQDATA) is stored in two locations, the Aquatic Biology Section of TDH Environmental Laboratories and PAS.

Chemical and bacteriological data are sent to EPA's STORET database. STORET is a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others. The STORET website http://www.epa.gov/STORET/ includes data retrieval instructions. Data retrievals also can be made by querying the WQDB and EDAS.

PART C

ASSESSMENT AND OVERSIGHT

C1 ASSESSMENTS AND RESPONSE ACTIONS

C1.1 Purpose/Background

During the planning process, many options for sampling design, handling, cleanup and analyses, and data reduction were evaluated and chosen for this project. In order to ensure data collections are conducted as planned, a process of evaluation and validation is necessary. This element of the QAPP describes the internal and external checks necessary to ensure:

1. all elements of the QAPP are correctly implemented as prescribed,
2. the quality of the data generated by implementation of the QAPP is adequate, and
3. corrective actions, when needed, are implemented in a timely manner and their effectiveness is confirmed.

EPA, Region 4, conducts any external assessments. The most important part of this element is documenting all planned internal assessments. Generally, internal assessments are initiated or performed by the designated internal QAPP Manager. The activities described in this element are related to the responsibilities of the QAPP Manager as discussed in Section A4.

C1.2 Organizational Assessments

Readiness reviews. A readiness review is a technical check to determine if all components of the project are in place so work can commence on a specific phase. A readiness review will be conducted in conjunction with annual 106 program plan development to ensure sufficient equipment, staffing, and funding are available. EFO managers communicate any needs to the QAPP Project Manager (Garland Wiggins) during the readiness review. At a minimum, the following issues will be addressed:

1. Availability and accessibility of an up-to-date copy of the Quality Assurance Project Plan and all associated quality system standard operating procedures relating to the project.

2. Availability of current reference documents including the following:

    - Most recent *Tennessee WPC Monitoring and Assessment Program Plan* (TDEC, 2009)
    - Most recent *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006)
    - Most recent *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2009)
    - Most recent version of the *303(d) List* (TDEC, 2008)

- Most recent version of the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010)
- *Rules of TDEC Division of WPC*, Chapter 1200-4-3 General Water Quality Criteria (TDEC-WQCB, 2007)
- *Rules of TDEC Division of WPC*, Chapter 1200-4-4 *Use* Classifications of Surface Waters (TDEC-WQCB, 2007)

3. Availability of electronic data sources including:

   - EQUIS
   - STORET
   - ADB
   - WQDB
   - On-line Water Quality Assessment Database

4. Availability of equipment, operating and calibration instructions for the equipment, records sheets and other necessary supplies.

5. Availability of appropriate sampling supplies and equipment.

6. Proper alignment of appropriate laboratory to receive the samples and accessibility of lab sheets, tags, and other necessary supplies.

7. Availability of staff.

8. Appropriate training of staff and opportunity for staff to resolve questions, concerns and issues prior to the onset of the project.

C1.3 Assessment of Project Activities

1. *Readiness Review.* Monitoring, analyses, and assessment staff are contacted to ensure appropriate equipment, staffing, and funding are available.

2. *Surveillance.* Surveillance is the continual or frequent monitoring of the status of a project and the analyses of records to ensure specified requirements are being fulfilled. PAS staff will maintain contact with EFO staff concerning project status and review databases for data gaps.

3. *Technical Systems Audit (TSA).* A TSA is a thorough and systematic onsite qualitative audit, where facilities, equipment, personnel, training, procedures, and record keeping are examined for conformance to the QAPP. It has broad coverage and its application may reveal weaknesses in management structure, policy, practices, or procedures. The TSA is

ideally conducted after work has commenced, but before it has progressed very far, thus giving opportunity for corrective action.

Garland Wiggins (Deputy Director and QAPP Project Manager) will conduct audits to determine if the project is on-task. A quarterly visit is made to each field office to conduct routine surveillances of various project activities and assist staff in addressing on-going concerns. The audit checklist is included in Appendix F. Oral reports are given to the Division Director and appropriate immediate changes are performed. When necessary, the findings and actions are documented in a written report.

4. *Performance Evaluation (PE).* A PE is a type of audit in which the quantitative data generated by the measurement system are obtained independently and compared with routinely obtained data to evaluate the proficiency of an analyst or laboratory. "Blind" PE samples are those whose identity is unknown to those operating the measurement system. Blind PEs often produce better performance assessments because they are handled routinely and are not given the special treatment undisguised PEs sometimes receive. TDH Environmental Laboratories perform blind PE studies each year on specific parameters according to protocols described in the *Environmental Laboratories Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004).

5. *Audit of Data Quality (ADQ).* An ADQ reveals how the data were handled, what judgments were made, and whether uncorrected mistakes were made. Data are reviewed by PAS technical staff prior to use and production of a project's final report. ADQs identify the means to correct systematic data reduction errors.

6. *Management System Review.* Management system review is a quality function as well as a function for scientific review of the plan. An extensive review team was used for this project. Names, titles, and positions of the reviewers are included in Appendix G of this QAPP. Also included are their report findings, the QAPP authors' documented responses to their findings, and reference to where responses to review comments are on file, if necessary.

7. *Data Quality Assessment (DQA).* DQA involves the application of statistical tools to determine whether the data meet the assumptions that the DQOs and data collection design were developed under and whether the total errors in the data are tolerable. *Guidance for Data Quality Assessment* (USEPA QA/G-9, 2000) provides non-mandatory guidance for planning, implementing, and evaluating retrospective assessments of the

quality of the results from environmental data operations. This document is used as guidance by WPC when reviewing data for this project.

C1.4 Assessment Personnel

Internal audits will be performed by the QAPP Project Manager. Qualifications of assessment personnel and considerations for assessments are specified in TDEC's Quality Assurance Program Plan (QAPP) and will be followed during this project. Key assessment personnel are identified in Table 47. In the event deviations from the QAPP are needed to efficiently conduct this program component, the issue will be discussed with the QAPP Manager and documented in the assessment report provided as part of this project.

Table 47: Assessment Activities Personnel

Assessment Activities	**Responsible Personnel**
Readiness Review	EFO Managers
Surveillance	PAS staff
Technical System Audit	QAPP Manager
Performance Evaluation	Assistant Director of Environmental Laboratories
Audits of Data Quality	PAS Staff
Management System Review	Planning Team Members
Data Quality Assessment	PAS Staff

C1.5 Number, Frequency, and Schedule of Assessment Activities

This section specifies the schedule of audit activities and relevant criteria for assessment, to the extent it is known in advance of project activities. Specifics will be developed in conjunction with the assessment and with current needs at the time. The QAPP will be reviewed annually and revised as necessary. Table 48 lists the minimum QAPP assessment schedule.

Table 48: QAPP Assessment Schedule

Assessment Type	Frequency	Approx. Date	Type (oral, written or both)	Minimum number of reports
Readiness review	Annually	January	Both	1
Surveillance	Monthly	End of Month	Both	1
Technical system audit	Quarterly	January April July October	Both	4
Performance evaluation	Annually	Varies	Written	4
Audits of data quality	Annually	September	Both	1
Management System review	Once/ Revision	September	Written	Per revision
Data quality assessments	Annually	September	Both	1

C1.6 Reporting and Resolution of Issues

Audits, peer reviews, and other assessments often reveal practice or procedure findings that do not conform to the written QAPP. This section defines the protocol for resolving them. Proposed actions to ensure corrective actions were performed effectively are specified in this section. The staff person to whom concerns should be addressed, decision-making hierarchy, schedule and format for oral and written reports, and responsibility for corrective action are also discussed.

Findings from the assessments conducted shall be included in a written report. The format of the report and information to be included will comply with at least the minimum requirements of the *Environmental Programs Quality Management Plan* (TDEC, 2005) for assessment reports. These reports are filed in PAS. For the purposes of this QAPP, assessment reports shall be made available to the division director.

In reviewing and responding to the report findings, the director may appoint a staff person or committee to conduct required activities. This person or committee shall be empowered to act on behalf of the director to correct any items addressed in the assessment. For conflicts that may arise during the course of this project or any of its assessments, the process defined in the *Environmental Programs Quality Management Plan* (TDEC, 2005) shall be followed. All issues relating to this QAPP shall be appropriately documented and attached to this document.

C2 REPORTS TO MANAGEMENT

This section describes documentation and reporting requirements for the assessment activities described in Section C1. Reports to management include project status, results of assessments and significance of quality assurance and recommended solutions.

C2.1 Purpose/Background

Effective communication between all personnel is an integral part of a quality system. Planned reports provide a structure for apprising management of the project schedule. Deviations from approved QA and test plans, impact of these deviations on data quality, and potential uncertainties in decisions based on the data shall be included in these reports.

C2.2 Frequency, Content, and Distribution of Reports

This QAPP indicates frequency, content, and distribution of reports so management may anticipate events and move to improve potentially adverse results. An important benefit of the status reports is the opportunity to alert management of data quality problems, propose viable solutions, and procure additional resources (Table 49).

If program assessment (including technical systems evaluations, the integrity of performance measurement and data assessment) is not conducted on a continual basis, data integrity generated in the program may not meet quality requirements. QAPP Reports will be stored in the central office for at least five years. These audit reports (Table 50), submitted in a timely manner, provide an opportunity to implement corrective actions when most appropriate.

Table 49: Project Status Reports

Project Status Reports	Frequency	Distribution
Monthly activity reports	Monthly	CO Managers Deputy Director EFO Managers
Quarterly Activity Reports	Quarterly	USEPA WQCB Bureau of Environment CO Managers Deputy Director EFO Managers
Performance Results Report	Quarterly	TDEC Planning Division
Tennessee Division of Water Pollution Control Monitoring and Assessment Program Plan	Annually	USEPA CO Managers EFO Managers
Annual Performance Report	Annually	USEPA
106 Electronic Workplan	Annually	USEPA CO Managers EFO Managers
EFO Audits	Quarterly	EFO Managers QAPP Manager
Data Audits	Continuously	TDH Environmental Labs QAPP Manager
Data Quality	Continuously	QAPP Manager
QA Audit Report	Annually	QAPP Planning Team Members

Table 50: QAPP Reports

Assessment Report Type	Report Frequency	Report Preparer	Report Distribution
Readiness review	Annually	EFO managers, supervisors	Garland Wiggins Larry Bunting
Surveillance	Annual	PAS staff	EFO Managers Greg Denton Garland Wiggins
Technical Systems Audit	Quarterly	Garland Wiggins	EFO Managers PAS staff
Performance Evaluation	Annually	TDH Env. Lab staff	Paul Davis Garland Wiggins Greg Denton Sherry Wang
Audits of Data Quality	Annually	PAS and WMS (TMDL) staff	Paul Davis Garland Wiggins Greg Denton Sherry Wang EFO Managers
Management Systems Review	Per Revision	PAS staff	Paul Davis Garland Wiggins Greg Denton
Data Quality Assessments	Annually	PAS and WMS (TMDL) staff	Paul Davis Garland Wiggins Greg Denton Sherry Wang EFO Managers

C2.3 Report Description

A written report of findings from the assessments conducted shall be prepared. The format of the report and information to be included will comply with at least the minimum requirements of the *Environmental Programs Quality Management Plan* (TDEC, 2005) for assessment reports. Report descriptions are listed in Table 51.

Table 51: Report Descriptions

Assessment Report Type	Type of response required as result of assessment report findings
Readiness review	Report monitoring staff, equipment, supplies, reference, and training needs to the deputy director.
Surveillance	PAS/WMS (TMDLs) inform EFOs if additional data are needed.
Technical systems audit	EFOs take necessary steps to repair audit deficiencies.
Performance Evaluation	TDH Environmental Laboratories will provide report and support documentation regarding analyses discrepancies with Blind PEs.
Audits of data quality	PAS staff will work with TDH Environmental Laboratories and EFOs to improve data quality.
Management Systems Review	All peer review comments will be considered and applicable comments will be included in QAPP revisions.
Data Quality Assessment	Steps will be taken to insure data assessments follow valid design and statistical analyses as outline in *Guidance for Data Quality Assessment* (USEPA QA/G-9, 2000).

It is recognized that changes made in one area or procedure may affect another part of the project. Documentation for all changes shall be maintained and included in the reports to management. The procedure specified in the Documents and Records Section of *Environmental Programs Quality Management Plan* (TDEC, 2005) shall be followed in documenting and maintaining all documents, changes and distribution of documents and changes to them. Deviations from this procedure may be obtained by working with TDEC's Quality Assurance Manager and documenting them in a report attached to this QAPP.

PART D

DATA VALIDATION AND USABILITY

D1 DATA REVIEW, VERIFICATION, AND VALIDATION REQUIREMENTS

Data verification is defined by EPA as "the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. Data validation is defined by EPA as an "analyte- and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance to determine the analytical quality of a specific data set". Tools and techniques used to meet the data quality goals of Tennessee's state-wide water quality monitoring program, including data integrity and data suitability, are discussed in this section.

One of the responsibilities of each project or task supervisor and manager is to review, verify, and validate all data collected in the field and laboratory to determine if the data meet QAPP objectives. This includes quantitative, qualitative, and narrative data. Completeness and correctness of records and data are primary goals of the verification and validation process. The review, verification and validation process starts from the beginning of any project and continues throughout.

All sampling equipment are checked by the field team members prior to sampling. The integrity of the equipment is determined at that time. Equipment manuals for each make and model of sampling and field equipment are referred to when the integrity of the equipment has been compromised. Corrective actions are taken in accordance to the equipment manual instructions and recorded in the equipment log book. Field water parameter meters and flow meters are calibrated at the regional field offices. Protocol J in the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) describes calibration methods, record keeping, and QA/QC requirements for each instantaneous field parameter. The field log books, equipment log books, and forms are reviewed for errors by the field team members prior to sending the data to PAS. When field equipment results are outside the calibration range during post drift checks, results are flagged with an N (uncertain of results). PAS is notified by email if data were already recorded, and flagged in the water quality database (WQDB) accordingly. Any analyses flagged by the TDH Environmental Laboratories are viewed with caution and excluded when outside of the existing data set. Flags used are listed in Table 32.

Field collection, handling, and documentation procedures for chemical and bacteriological samples are specified in Protocols A-I of the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009). Data acquired in the field are recorded in a log book and on appropriate field forms at the sample site and checked by the field team members. Data collected during rainfall are flagged with an R (rain event) and viewed with caution. All field data are checked by the field team members for field record consistency and QC information. Sample collection, deviations in the data, and impacts on data quality are reviewed by the responsible environmental field office

supervisor and verified. The data are then transmitted electronically and a hard copy of the data is sent to PAS. The data are checked by PAS for discrepancies and errors. When an error is found, the field team members are contacted about the error. Once the data are validated they are entered into the WQDB. Field log books and forms are kept in the field offices and are available for supplementary review if needed. Table 52 lists examples of improper field practices that would compromise field data and the warning signs that are checked by PAS (Adapted from EPA QA/G-8, 2002).

Table 52: Warning Signs of Improper Field Sampling Practices

Improper Practice	Description	Warning Signs
Improper Sampling	Collection of biological samples from an area with inappropriate habitat or from an area other than the actual sample location	Macroinvertebrate data inconsistent with historical or known biological index scores and metrics
	Collection of water samples from an area of known contamination to increase contaminant concentration, mixing known contaminated water samples with water from the actual sample location, or directly adding a contaminant to the sample	Inconsistencies among sample collection logs, field notebook, photos, and COC Laboratory notes that the water samples were not homogenous
	Collection of water samples from an area known as "clean" or collecting samples from somewhere else entirely different from the actual sample location and forging the location information	Data with concentrations lower than historical or known concentrations at the sample location
	Collecting many samples from one location to avoid the time/cost of sampling other required locations	Similar results for samples from multiple station locations
Mislabeled Sample Containers	Misrepresenting the sample date, location, or other key parameter by falsifying information on the sample container label	Crossed-out information, inconsistent information between the field logs, collection logs, and the sample label
Documentation Issues	Filling in field sheets and log books improperly	Inconsistencies among field logs, collection logs, sample labels, sample locations, and times between samples

Field collection, handling, and documentation procedures for macroinvertebrate samples are specified in Protocols A-L of the *QSSOP for Macroinvertebrate Stream Surveys*

(TDEC, 2006). Biological samples with fewer than 160 organisms found in a SQSH sample are flagged and results are viewed with caution. The site is re-sampled if necessary to obtain acceptable results. All biological samples are checked by the taxonomist and the Aquatic Biology Laboratory supervisor. Sample collection, deviations in the data, and impacts on data quality are reviewed by the laboratory supervisor and verified. The data are transmitted electronically and a hard copy of the biological data is sent to PAS. The data are checked by PAS for discrepancies and errors. When an error is found, the field team members are contacted about the error. Once the data are validated, they are entered into the WQDB. Field sheets, forms, and log books are kept in the field office and laboratory and are available for supplementary review if needed.

Field collection, handling, and documentation procedures for periphyton samples are specified in Section I Protocols A-H of the *QSSOP for Periphyton Stream Surveys* (TDEC 2010). A Rapid Periphyton Sample and a Multi-habitat Periphyton Sample will be collected. All periphyton samples are to be sent to the central lab for analysis. This is to be coordinated through the Planning and Standards Section.

Field, trip, equipment blanks, and collected samples are sent to the laboratory for analysis. All samples examined by the laboratory are analyzed according to methods described in the *Environmental Inorganic SOPs* (TDH, 2002-2009) and the *Environmental Organic SOPs* (TDH, 2002-2009). When contamination is found in the blanks, the field team members and the laboratory supervisor are contacted to determine and correct the source of contamination. All samples collected that day by the same team are viewed with caution, and excluded from the data set if outside of the existing range. Duplicate, laboratory fortified blanks, spikes, and method blanks that fail to meet goals are immediately reviewed for the source of error and samples analyzed that day are viewed with caution, and excluded from the data set if outside of the existing range. Laboratory log books and forms are kept at the TDH laboratories and are available for supplementary review if needed. PAS is notified by email if data were already recorded, and flagged in the WQDB accordingly.

Sometimes the source of error in chemical data is due to instrument inaccuracy or failure. Instruments are calibrated, maintained, and repaired according to the specifications in the instrument instructions manual. Calibration records must be kept in log books in the laboratory. The calibration of each instrument are performed with a minimum of three concentrations of standards for linear curves, a minimum of five concentrations of standards for nonlinear curves, or as specified by the method of choice. When the calibration verification is out of control, the source of error is determined and corrective action is taken. Any instrument that fails QC procedures outlined in the *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2002-2009) and in the *Environmental Organic Chemistry Laboratory Quality Assurance Plan* (TDH, 2002-2009) is not be used until the problem is corrected. All data from samples analyzed that day by the same instrument are viewed with caution, and excluded from the data set if

outside of the existing range. Any samples affected by instrument inaccuracy or failure should be reanalyzed once the problem is resolved. The source of error and corrective action, as well as any results from reanalysis should be recorded in the laboratory log book. PAS is notified by email if data were already recorded, and flagged in the WQDB accordingly.

Some data acquired in the laboratory are automatically entered into the LIMS system. The automated calculations and algorithms used for the calculations were verified during the installation of the system. Data are periodically checked by the laboratory analyst by recalculating results produced by the automated system. Instrument outputs or recorded measurements for samples and standards, along with sample-specific preparation information are used for "raw data calculation verifications". Prior to transmitting the data, it is reviewed by the laboratory analytical supervisor and verified. It is transmitted electronically and a hard copy of the data is sent to PAS. The data is checked by PAS for discrepancies and errors. When an error is found, the laboratory analyst is contacted about the error. Once the data are validated, they are entered into the WQDB. Table 53 lists examples of improper laboratory practices that would compromise chemical data and the warning signs that are checked by PAS (Adapted from EPA QA/G-8, 2002). Laboratory log books and forms are kept at the TDH laboratories and are available for supplementary review if needed.

Table 53: Warning Signs of Improper Laboratory Practices

Improper Practice	Description	Warning Signs
Drylabbing	Reporting results without analyzing samples	Overlapping analysis times on the same instrument
QC Issues	Failure to conduct specified analytical steps by reporting previously conducted successful QC results instead of conducting specified QC analyses	QC measurements that are identical to those submitted in the past. Inadequate run times for sample analysis (may suggest that specified QC checks were skipped)
Manipulation of Sample Prior to Analysis	Fortifying water sample with additional analyte	High chemical concentrations for chemicals that are typically found to be low at the location the sample was collected.

Table 53: Warning Signs of Improper Laboratory Practices (Continued)

Improper Practice	Description	Warning Signs
	Overdilution of a sample	Low chemical concentrations or undetects for chemicals that are typically found to be high at the location the sample was collected.
Manipulation of Results During Analysis	Peak shaving – manually adjusting results to produce a desired outcome	Repeated manual integrations, especially on QC measurements
	Time-traveling – falsifying date of analysis to disguise exceedance of holding times	Inconsistencies in dates for holding times, extractions, and analyses
Manipulation of Results After Analysis	Figures transposed to produce a desired result	Erased or handwritten changes in the printed data report
	Laboratory selection of preferred data from a larger data set	Raw data incompatible with calculated results

Data review, verification, and validation for all of WPC monitoring projects are completed internally at the field offices, laboratory, and central office. Required records and logs used in the verification and validation process are discussed in section A9 of this QAPP. Documents used to review, verify, and validate data are as follows:

Rules of TDEC Division of WPC, Chapter 1200-4-3, Use Classifications for Surface Waters. 2007
Rules of TDEC Division of WPC, Chapter 1200-4-4, General Water Quality Criteria. 2007
Final Version Year 2008 303(d) List
QSSOP for Macroinvertebrate Stream Surveys 2006
QSSOP for Chemical and Bacteriological Sampling of Surface Waters 2009
Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers 1999
Development of Regionally-Based Interpretations of Tennessee's Narrative Nutrient Criteria 2001
Development of Regionally-Based Interpretations of Tennessee's Existing Biological Integrity Criteria 2001
Habitat Quality of Least-Impacted Streams in Tennessee 2001

D2. VERIFICATION AND VALIDATION METHODS

D2.1 Process for Verifying Data

TDEC Environmental Field Office personnel verify data produced by the field office in-house. The data are reviewed by the field team members and other EFO personnel. When the data are received by PAS staff, they are reviewed for unusual or unlikely results. EFO field staff are contacted about questionable field data. Documents such as sample collection logs, field screening results, field log books, field meter calibration logs, and COC records are also used in the review process for data verification.

TDH Environmental Laboratories personnel verify data produced by the laboratory in-house. When analyses results from TDH Environmental Laboratories are received by PAS staff, the data are reviewed. The appropriate TDH Environmental Laboratory analytical supervisor is contacted to confirm unusual or unlikely results (outliers). The *Environmental Inorganic Chemistry Laboratory Quality Assurance Plan* (TDH, 2004) provides additional information. Documents such as hard copies of the raw data, bench notes, calibration log books, lab notebooks, internal tracking forms, and COC records are also used in the review process for data verification.

There is no specific software used for data verification. Data receipt and verification audit forms are in Appendix F. Table 54 lists the personnel responsible for data verification and resolution procedures.

Table 54: Data Verification Process and Resolution Procedures

Data Quality Check Points	Person Responsible for Verification	Issue Resolution
Biological Check Points		
Biological logs	In-house QC Officer*	Contact sampler and/or TDH Aquatic Biology Laboratory
Biological QC logs	In-house QC Officer*	Contact sampler and/or taxonomist
Taxa list entry in SQDATA	TDH Aquatic Biology Laboratory Supervisor	Contact taxonomist
Biological scoring	PAS staff	Contact taxonomist
WQDB entry	PAS staff	Contact data entry personnel
Field Meter Check Points		
Calibration logs	In-house QC Officer*	Contact Sampler
QC readings	In-house QC Officer*	Contact Sampler

Table 54: Data Verification Process and Resolution Procedures (Continued)

Chemical and Bacteriological Check Points		
QC sample collections	In-house QC Officer*	Contact Sampler
Analyses QC	TDH Analytical Supervisor	Contact Analyst
Data review	PAS staff	Contact Analyst
WQDB entry	PAS staff	Contact data entry personnel

* In-house QC officer refers to the TDEC EFO staff member designated by the manager to ensure quality control measures are applied and performed in accordance with the SOPs.

D2.1.1 Field Data Verification

Field data are verified according to the *QSSOP for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2009) the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010). Section II of these documents provides details about QA/QC activities. The field team members take duplicate field measurements at 10% of the sampling locations to verify data quality in the field. The field team members, and Environmental Field Office supervisors are responsible for verifying COC, receipt log, field log book, field meter calibration log, and that all applicable quality assurance protocols are properly followed for collection of data in the field. The field team members flag any questionable data.

When field data are received from the Environmental Field Offices, PAS staff review the data for unusual or unlikely results (outliers). Field staff are contacted concerning any questionable information or data. Field staff review equipment calibration logs and field notes to verify results. PAS staff make corrections on associated paper work, documentation, and in the WQDB.

D2.1.2 Chemical and Bacteriological Data Verification

Chemical data are verified according to the *Environmental Organic SOPs* (TDH, 2002-2009) and the *Environmental Inorganic SOPs* (TDH, 2002-2009). Bacteriological data are verified according to *Standard Methods for Examination of Water and Waste Water* SM9000 (APHA, 1995). The SOPs and Standard Methods provide details about QA/QC activities. Duplicate samples, blank samples, and standards are analyzed to verify data quality in the laboratory. TDH Environmental Laboratories personnel are responsible for verifying COC, receipt log, TDH calibration logs, and that all applicable quality assurance protocols are properly followed for chemical and bacteriological analyses. The TDH Environmental Laboratory analytical supervisor is responsible for chemical and bacteriological final data verification and ensuring the results are mailed to the data users. The lab flags any questionable data.

When chemical and bacteriological data are received from TDH Environmental Laboratories, PAS staff review the data for unusual or unlikely results (outliers). The appropriate lab manager is contacted by email regarding any questionable results. The lab manager reviews sample analyses, blanks analyses, and data recording errors. Issues with TDH Environmental Laboratories analyses results are documented in the Verification Database. The corrections are emailed to PAS. PAS staff make corrections on associated paper work, documentation, and in the WQDB.

D2.1.3 Biological Data Verification

All biological data are verified through quality control checks described in Section II of the *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) and the *QSSOP for Periphyton Stream Surveys* (TDEC, 2010) The field team members take duplicate samples at 10% of the sampling locations to verify data quality in the field. The Environmental Field Office personnel are responsible for verifying COC, receipt log, taxa lists, and that all applicable quality assurance protocols are properly followed for macroinvertebrate collection and analysis. The TDH Aquatic Biology Laboratory supervisor is responsible for final biological data verification and ensuring the results are mailed to the data users. The lab flags any questionable data.

When biological data are received by PAS, taxa lists and biological scoring are reviewed. When discrepancies in scoring are found, PAS contacts the appropriate lab manager and taxonomist that identified the sample to discuss differences in scoring. Once the discrepancies are corrected and agreed upon, PAS staff make corrections on associated paper work, documentation, and in the WQDB.

D2.2 Process for Validating Data

Verified data are validated to determine the analytical quality of the data set. Data validation applies to data acquired in the field and in the laboratory. The goal of validation is to determine data quality. Once data are reviewed and verified by the responsible field and laboratory staff, the project or task supervisor validates the data. Oftentimes professional judgment is exercised in order to maximize the benefits of the data validation process. Any corrections or changes to the verified data are reflected in the validated data and a record of those corrections or changes is kept.

D2.2.1 Field Data Validation

Documents such as sample collection logs, field screening results, field log books, field meter calibration logs, and COC records are reviewed for data validation. Field records are reviewed for consistency. Quality control information is reviewed for completeness and correctness. Any deviations such as changes in sample locations, samples collected, sample analyses, time, or unusual readings from field meters are considered during the

validation process for their effect on data quality. All field data results are compared to the data quality objectives presented in the division's program plan (TDEC, 2009). Once the data are validated, they are entered into the WQDB. Any field data limitations are recorded in the field notes stored in the watershed files and in the comment column of the WQDB.

D2.2.2 Chemical and Bacteriological Data Validation

Documents such as hard copies of the raw data, bench notes, calibration log books, lab notebooks, internal tracking forms, and COC records are reviewed for data validation. Laboratory log books and notebooks are reviewed for consistency. The calculations used to determine sample results are checked for accuracy. Quality control checks such as duplicates, blanks, and standards are reviewed for completeness and correctness. Any QC deficiencies are considered during the validation process to determine their effect on data quality. All chemical and bacteriological data results are compared to the data quality objectives presented in the division's program plan TDEC, 2009). Once the data are validated, they are entered into the WQDB. Any bacteriological or chemical data limitations are recorded in the laboratory notebooks and are flagged in the WQDB.

D2.2.3 Biological Data Validation

Documents such as sample collection logs, field log books, lab notebooks, internal tracking forms, and COC records are reviewed for data validation. Laboratory log books and notebooks are reviewed for consistency. Taxa lists and biological scoring are reviewed for completeness and correctness. Quality control checks such as duplicate samples are reviewed for conformity. Any QC deficiencies are considered during the validation process to determine their effect on data quality. All biological data results are compared to the data quality objectives presented in the division's program plan (TDEC, 2009). Once the data are validated, they are entered into the WQDB. Any biological data limitations are recorded in the field and laboratory notebooks and are noted in the comment column of the WQDB.

D3. RECONCILIATION WITH USER REQUIREMENTS

Reconciliation is the final assessment of data quality and the conclusion of the quality assurance process. Once the review, verification, and validation process is completed, assessment of the data quality is applied to the data quality objectives presented in the division's program plan (TDEC, 2009). This ensures data credibility for defensible decisions. EPAs five-step process for data quality assessment is followed (EPA QA/G-9, 2000):

- Review the Data Quality Objectives and Sampling Design
- Conduct a Preliminary Data Review

- Select the Statistical Test
- Verify the Assumptions of the Statistical Test
- Draw Conclusions from the Data

D3.1 Review the Data Quality Objectives and Sampling Design

The monitoring and assessment objectives as outlined in Part A5 of this document and the data quality objectives as outlined in Part A7 of this document are reviewed to determine how the data will be evaluated. Sampling design is dependent upon the type of monitoring specified. Although sample design may be different for each type of monitoring, all samples are collected and measured following the same protocols and are not dependent on the type of monitoring. The statewide monitoring program is comprehensive and is outlined in Part B1 of this document. Activities involved in each five-year cycle include planning and data collection, monitoring, assessment, TMDL determination and wasteload allocation, permit issuance, and development of watershed management plans.

D3.2 Conduct a Preliminary Data Review

The first activity of the preliminary data review is to review the quality assurance documentation associated with the data collection and reporting process. The type of data acquired, listed in Table 8, is dependent on the monitoring objectives. Any anomalies in recorded data, missing values, or deviations from sample location and design are addressed. At this stage, the data have been verified and validated and are ready for use. In the event data at this point cannot be validated and reconciled with data quality objectives, it is removed from the data set. If possible, additional monitoring is conducted. PAS staff are responsible for ensuring data reconciliation or data removal, if reconciliation is not possible. All values within a data set that are below detection limits are given a value of half the detection limit. Hypotheses are constructed about the data set. Statistical quantities are computed. In addition to statistical methods, graphical representations of the data are used to identify patterns or trends. Specific statistical methods and graphical representations employed are determined by the data quality objectives for each type of monitoring.

D3.3 Select the Statistical Test

The results of the preliminary data review are used to determine which statistical test is legitimate for the type of data collected for each type of monitoring. The statistical test chosen is based on the data quality objectives, preliminary data review, and assumptions concerning the particular data set or sample site and the hypotheses about the data set. Once a test is chosen, the underlying assumptions of the test are identified as appropriate for the data set. Once the test and underlying assumptions are determined to be appropriate for the data set, it is further determined how sensitive or robust the test is to

departures from the underlying assumptions. Specific tests of hypotheses are listed in Part B5 of this document. When an objective is to compare data to a fixed threshold of regulatory limit, the appropriate hypothesis tests in Section 3.2 of EPA's *Guidance for Data Quality Assessment Practical Methods for Data Analysis* (EPA QA/G-9, 2000) are selected for use. When an objective is to compare data from different locations or processes, the appropriate hypothesis tests in Section 3.3 of EPA's *Guidance for Data Quality Assessment Practical Methods for Data Analysis* (EPA QA/G-9, 2000) are selected for use.

D3.4 Verify the Assumptions of the Statistical Test

The validity of the statistical test chosen is determined by examining the underlying assumptions in regard to the data set. The primary objective of this step in data reconciliation is to determine whether the data support the underlying assumptions of the test. This determination can be performed quantitatively using statistical analysis of the data to confirm or reject assumptions that accompany the test. Standard tests for normal distribution are conducted when adequate data are available. Once normality is confirmed other statistical methods are applied to test the hypothesis. Appropriate tests chosen for detecting and estimating trends, outlier tests, tests for dispersion, and tests for independence or correlation are determined by the hypothesis and the data set. When normality is rejected, the appropriate transformations are performed on the data set, such as a logarithmic transformation. Nonparametric tests are used when the data cannot be transformed to fit a normal distribution. The level of significance of each statistical test is determined by the amount of data in the data set, the hypothesis, and the statistical method chosen to test the hypothesis.

D3.5 Draw Conclusions from the Data

Specific quantitative conclusions are drawn from the data using statistical methods. Other conclusions drawn from the data are made using a qualitative approach. There are many aspects to the decision making process. Chemical, bacteriological, biological, and physical/habitat data are all used to assess water quality. To gauge Tennessee's progress toward meeting the goals of the *Federal Water Pollution Control Act* (U.S. Congress, 2000) and *Tennessee Water Quality Control Act* (TN Secretary of State, 1999), water quality data are compared to *Rules of the TDEC Division of WPC*, Chapter 1200-4-3, General Water Quality Criteria (TDEC-WQCB, 2007) and the Level IV Ecoregion reference data set (Table 7).

D3.5.1 Chemical Data

Chemical data collected are used in the water quality assessment process. The null hypothesis is that the waterbody associated with the data set does not exceed criteria or regional guidelines. The waterbody is considered unimpaired when 90% of the chemical data points fall within criteria or guidelines. The decision is made to not reject the null

hypothesis. Data sets from waterbodies that do not fulfill the requirements of the null hypothesis are considered impaired and the decision is made to reject the null hypothesis. When there are biological data and chemical data sets for a waterbody, best professional judgment is used in the assessment. Where chemical data exceed criteria and macroinvertebrate data indicate support of fish and aquatic life, the decision is based on the macroinvertebrate results. Any waterbody placed on the 303(d) list for impairment is revisited and additional data are collected to determine corrective action and identify TMDL development needs.

D3.5.2 Bacteriological Data

Bacteriological data collected are used in the water quality assessment process. The null hypothesis is that the waterbody associated with the data set does not exceed criteria. The waterbody is considered unimpaired when the calculated geomean and/or single criterion meet criteria. The decision is made to not reject the null hypothesis. Data sets from waterbodies that do not fulfill the requirements of the null hypothesis are considered impaired and the decision is made to reject the null hypothesis. When the calculated geomean meets criteria, but a single sample exceeds criteria due to rain, the decision is based on the criteria and best professional judgment. Any waterbody placed on the 303(d) list for impairment is revisited and additional data are collected to determine corrective action and identify TMDL development needs.

D3.5.3 Biological Data

Biological data collected are used in the water quality assessment process. The null hypothesis is that the waterbody associated with the data set does not fall below regional guidelines. The waterbody is considered unimpaired when the index values and/or biorecon scores meet or exceed regional guidelines. The decision is made to not reject the null hypothesis. Data sets from waterbodies that do not fulfill the requirements of the null hypothesis are considered impaired and the decision is made to reject the null hypothesis. When biorecon scores are ambiguous, the decision is based on habitat and/or chemical data. The decision, using best professional judgment, can be made to consider the waterbody unassessed until a single habitat semi-quantitative sample can be collected. Any waterbody placed on the 303(d) list for impairment is revisited and additional data are collected to determine corrective action.

D3.5.4 Physical/Habitat Data

Physical/habitat data collected are used in the water quality assessment process. The null hypothesis is that the waterbody associated with the data set does not fall below regional guidelines. The waterbody is considered unimpaired when the habitat scores meet or exceed regional guidelines. The decision is made to not reject the null hypothesis. Data sets from waterbodies that do not fulfill the requirements of the null hypothesis are considered impaired and the decision is made to reject the null hypothesis. Where the

habitat scores fall below regional guidelines and macroinvertebrate data indicate support of fish and aquatic life, the decision is based on the macroinvertebrate results. Any waterbody placed on the 303(d) list for impairment is revisited and additional data are collected to determine corrective action.

D3.6 Interpreting and Communicating Conclusions

Water quality assessments are completed by applying water quality criteria to the monitoring results to determine if waters are supportive of all designated uses. Water quality criteria are defined in Water Quality Standards published minimally every three years. The support or impairment status of a waterbody is entered in the Assessment Database (ADB). Impaired waterbodies are identified and listed on the 303(d) List published biennially. Waterbodies that pose a potential human health threat from fish tissue contamination or elevated bacteria levels are posted and are identified in the 305(b) Report published biennially. Waterbodies in need of TMDL development are identified through water quality assessments and reported per civil action (Tennessee Environmental Council et. al., 2001). Watershed management plans are updated every five years congruent with the watershed cycle and are made available to the public on the TDEC website at: http://state.tn.us/environment/wpc/watershed/wsmplans/

A final report is published for any special project funded through grant money in accordance with the grant requirements. All publications are made available to the public on the TDEC website at: http://state.tn.us/environment/wpc/publications/. Many are also available in hard copy.

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Appendix A:

ACRONYMS AND DEFINITIONS

LIST OF ACRONYMS

AB	Aquatic Biology
ADB	Assessment Database
ADQ	Audit of Data Quality
APHA	American Public Health Association
ARAP	Aquatic Resource Alteration Permit
BOD	Biochemical Oxygen Demand
BR	Biorecon
BS	Bachelor of Science
BTEX	Benzene toluene ethylbenzene xylene
$CaCO_3$	Calcium Carbonate
$CBOD_5$	5-day carbonaceous biochemical oxygen demand
$CBOD_u$	Ultimate carbonaceous biochemical oxygen demand
CHEFO	Chattanooga Environmental Field Office
CKEFO	Cookeville Environmental Field Office
CLEFO	Columbia Environmental Field Office
CFR	Code of Federal Regulations
CFU	Colony Forming Unit
CO	Central Office
COC	Chain of Custody
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DQA	Data Quality Assessment
DQI	Data Quality Indicator
DQO	Data Quality Objective
DVD	Digital video disk
E. coli	*Escherichia coli*
EDAS	Ecological Data Application System
EFO	Environmental Field Office
EPA	Environmental Protection Agency
EPH	Extractable petroleum hydrocarbons

List of Acronyms (Continued)

EPT	Ephemeroptera, Plecoptera, Trichoptera
ESRI	Environmental Systems Research Institute
ETW	Exceptional Tennessee Water
FAL	Fish and Aquatic Life
GIS	Geographic Information System
GRO	Gasoline range organics
HASP	Health and Safety Plan
HUC	Hydrologic Unit Code
IBI	Index of Biological Integrity
IS	Information Systems
ISO	International Organization for Standardization
JCEFO	Johnson City Environmental Field Office
JEFO	Jackson Environmental Field Office
JLAB	Jackson Laboratory
KEFO	Knoxville Environmental Field Office
KLAB	Knoxville Laboratory
KSM	Knoxville Surface Mining
MDL	Minimum Detection Limit
MEFO	Memphis Environmental Field Office
mg/L	Milligram per liter
MPS	Multihabitat Periphyton Survey
µg/L	Microgram per liter
µmhos	micromhos
NEFO	Nashville Environmental Field Office
NH_3	Ammonia
NHD	National Hydrology Dataset
NLAB	Nashville Laboratory
NPDES	National Pollution Discharge Elimination System
NO_2/NO_3	Nitrite/Nitrate
NTU	Nephelometric Turbidity Units
ONRW	Outstanding National Resource Waters
ORNL	Oak Ridge National Laboratory

List of Acronyms (Continued)

OSHA	Occupational Safety and Health Administration
PAS	Planning and Standards Section
PE	Performance Evaluation
QA	Quality Assurance
QAD	Quality Assurance Division (EPA)
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
QSSOP	Quality System Standard Operating System
RAM	Random Access Memory
RPS	Rapid Periphyton Survey
SOD	Sediment Oxygen Demand
SOP	Standard Operating Procedure
SQBANK	Semi-Quantitative Bank
SQDATA	Semi-Quantitative Database
SQKICK	Semi-Quantitative Kick
SQSH	Semi-Quantitative Single Habitat
STORET	Storage and Retrieval Database
TAL	Target analyte list
TCLP	Toxic characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TDEC-E	Tennessee Department of Environment and Conservation Bureau of Environment
TDH	Tennessee Department of Health
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TSA	Technical Systems Audit
TSS	Total Suspended Solids
TVA	Tennessee Valley Authority

List of Acronyms (Continued)

TWQCB	Tennessee Water Quality Control Board
TWRA	Tennessee Wildlife Resources Agency
USACE	United States Army Corp of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WMS	Watershed Management Section
WPC	Water Pollution Control
WQCB	Water Quality Control Board
WQDB	Water Quality Database

List of Definitions

Ambient Monitoring: Routine sampling and evaluation of receiving waters not necessarily associated with periodic disturbance.

Analyte: The chemical, physical or biological parameter(s) measured during sample analysis.

Assessment: The evaluation process used to measure the performance or effectiveness of a system and its elements. As used here, assessment is an all-inclusive term used to denote any of the following: audit, performance evaluation, management systems review, peer review, inspection, or surveillance.

Benthic Community: Animals living on the bottom of the stream.

Bias: Consistent deviation of measured values from the true value, caused by systematic errors in a procedure.

Bioassay: Exposure of biological organisms to a chemical(s), which determines the concentration of the chemical, that impairs or causes the death of the organism.

Biocriteria: Numerical values or narrative expressions that describe the reference biological condition of aquatic communities inhabiting waters of a given designated aquatic life use. Biocriteria are benchmarks for water resources evaluation and management decisions.

List of Definitions (Continued)

Biometric: A calculated value representing some aspect of the biological population's structure, function or other measurable characteristic that changes in a predictable way with increased human influence.

Bioregion: An ecological subregion, or group of ecological subregions, with similar aquatic macroinvertebrate communities that have been grouped for assessment purposes. Tennessee has defined 15 bioregions.

Chain-of-Custody: A procedure which documents the collection, transport, analyses and disposal of a sample by requiring each person who touches the sample to provide the date and time of sample collection/receipt and sample transfer/disposal.

Composite Sample: Composite samples can be time or flow proportional. Time integrated composite samples are collected over time, either by continuous sampling or mixing discrete samples. Flow proportional composite samples are composed of a number of samples sized relative to flow. Composite samples may also be combined manually by collecting grab samples at various intervals in a waterbody.

Diurnal Dissolved Oxygen: Cyclic fluctuations in dissolved oxygen levels of water between day and night.

Ecological Subregion (or subecoregion): A smaller area that has been delineated within an ecoregion that has even more homogenous characteristics than does the original ecoregion. There are 25 (Level IV) ecological subregions in Tennessee.

Ecoregion: A relatively homogenous area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, and other ecologically relevant variables. There are eight (Level III) ecoregions in Tennessee.

Ecoregion Reference: Least impacted waters within an ecoregion that have been monitored to establish a baseline to which alterations of other waters can be compared.

Flash point: Temperature at which a liquid will yield enough flammable vapor to ignite.

Grab Sample: Grab samples consist of either a single discreet sample or individual samples collected over a period of time not to exceed 15 minutes.

Habitat: The instream and riparian features that influence the structure and function of the aquatic community in a stream.

List of Definitions (Continued)

Macroinvertebrate: Animals without backbones that are large enough to be seen by the unaided eye and which can be retained by a U.S. Standard No. 30 sieve (28 meshes/inch, 0.595 mm).

Periphyton: Algae attached to submerged substrate in aquatic environments

Quality Assurance (QA): Includes quality control functions and involves a totally integrated program for insuring the reliability of monitoring and measurement data; the process of management review and oversight at the planning, implementation and completion stages of date collection activities. Its goal is to assure the data provided are of high quality and scientifically defensible.

Quality Control (QC): Refers to routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process; focuses on detailed technical activities needed to achieve data of the quality specified by data quality objectives. QC is implemented at the field or bench level.

Rain Event: A qualifying event is a precipitation event of 0.5 inches or greater in a 24 hour period.

Reference Database: Biological, chemical, physical, and bacteriological data from ecoregion reference sites.

Recommend: Advise as the best course of action. Synonyms: optional, may, should.

Require: Obligatory or necessary. Synonyms: must or shall.

Riparian Zone: An area that borders a waterbody (approximately 18 meters wide).

Split Sample: A sample that has been portioned into two or more containers from a single sample container or sample mixing container. The primary purpose of a split sample is to measure sample handling variability.

Thalweg: A line representing the greatest surface flow and deepest part of a channel.

Trace Metals: Low-level metal analyses requiring ultra-clean sample collection and laboratory analyses generally reported in the low parts per trillion range.

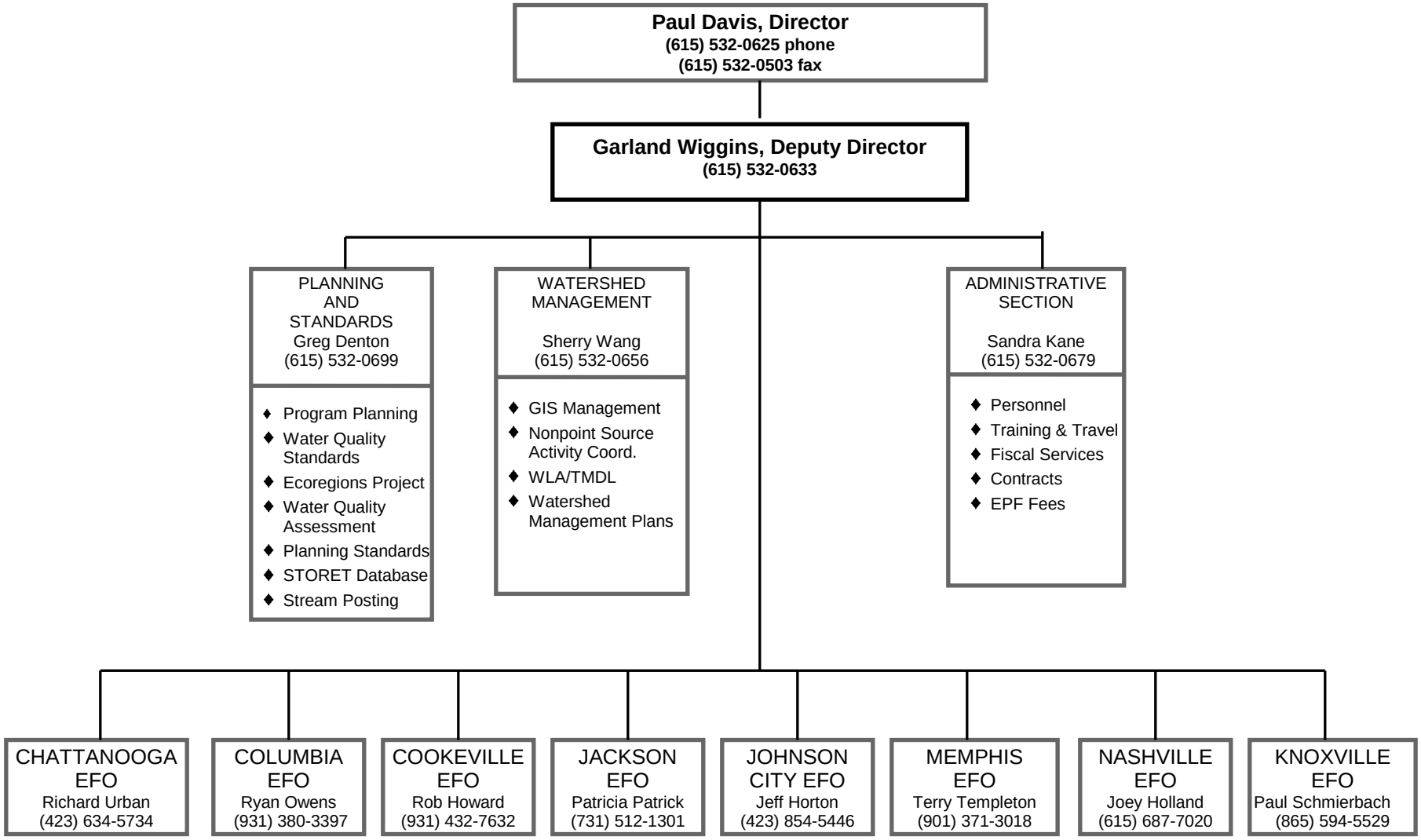
Wadeable: Rivers and streams less than 4 feet deep unless there is a dangerous current.

Watershed: The area that drains to a particular body of water or common point.

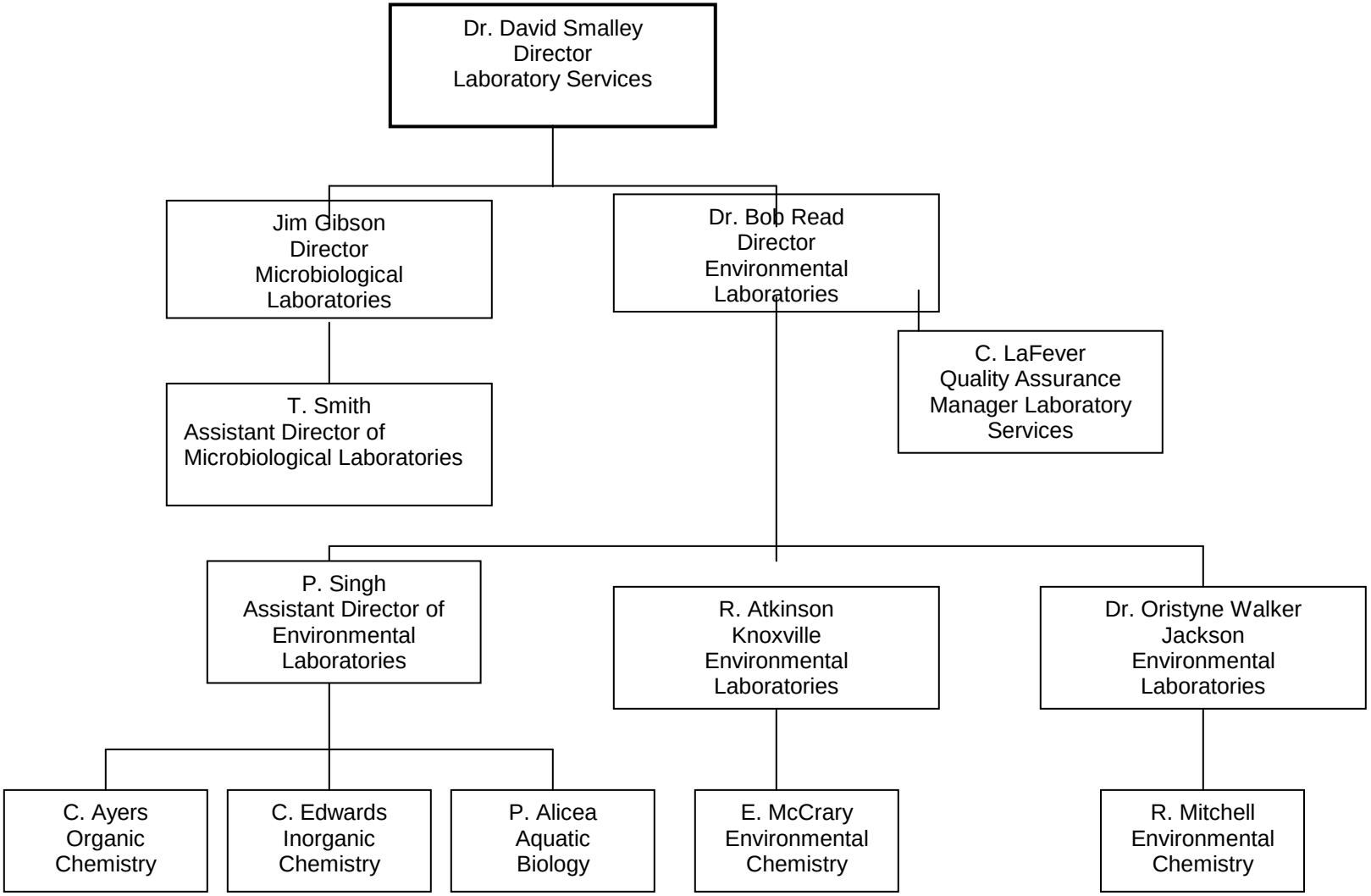
Appendix B:

ORGANIZATIONAL CHARTS

Organization of the Division of Water Pollution Control Monitoring Staff



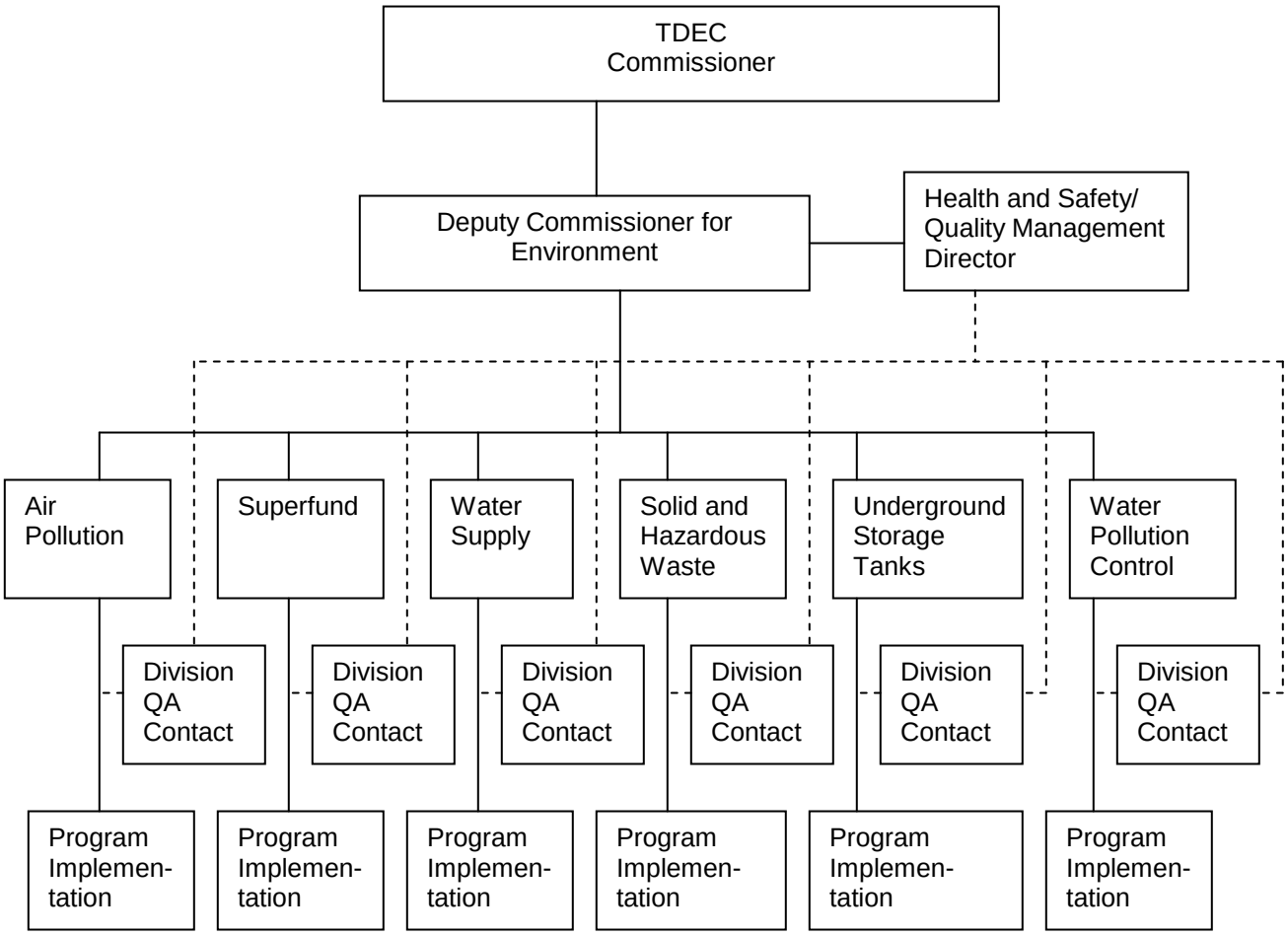
ORGANIZATION OF TDH LABORATORIES



TDEC Quality Management Program Organization

As required by EPA, TDEC-E's Quality Assurance Manager is responsible for quality system activities within TDEC-E. Specifically, the Quality Assurance Manager functions independently of direct environmental data generation, model development and technology development responsibility. This person reports on quality issues directly to the Deputy Commissioner for Environment and has free access to senior management on all issues relating to TDEC-E's quality system.

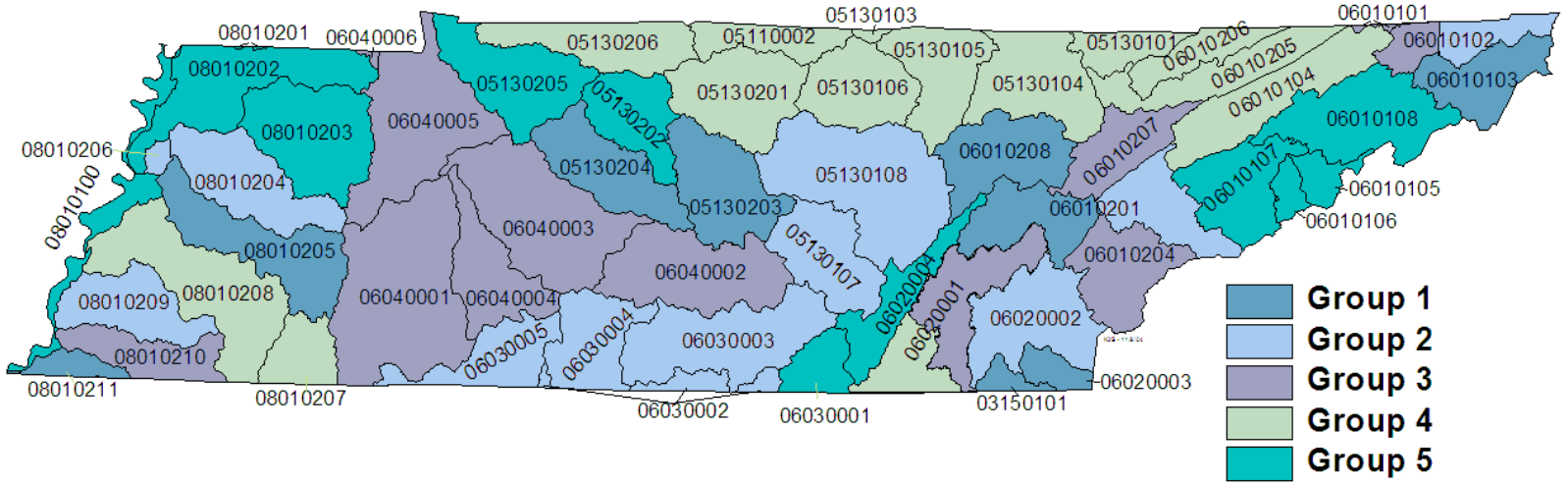
Quality Assurance Work Group members are independent of groups generating, compiling and evaluating environmental data and technology. The members are part of the Environmental Divisions included in the Quality Management Program. Members are responsible for participating in activities to ensure a quality system is established, implemented and maintained within their respective Division in accordance with TDEC-E's Quality Management Program and for reporting on the performance of the quality system to management for review and development of recommended improvements. The members participate in review of the quality system at defined internals and maintain appropriate records for the Division.



Appendix C:

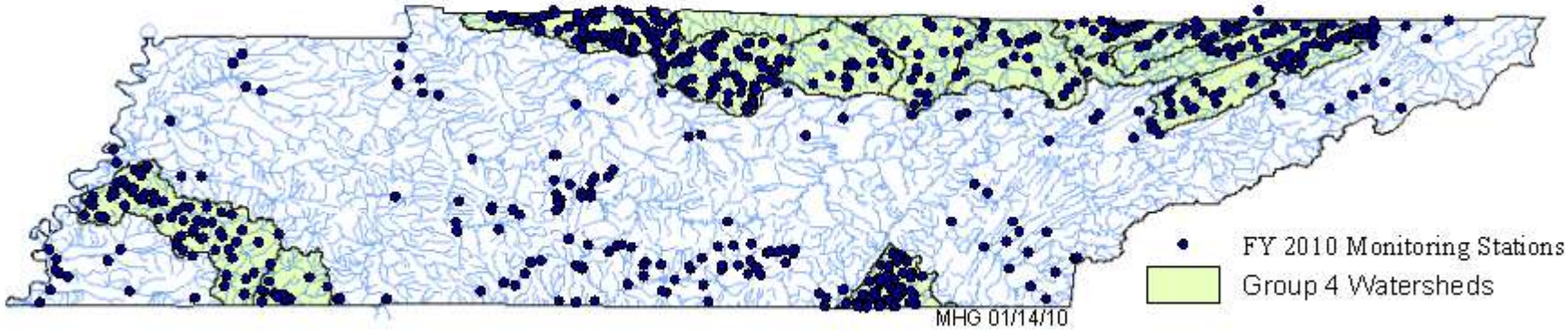
MAPS

Watershed Monitoring Groups

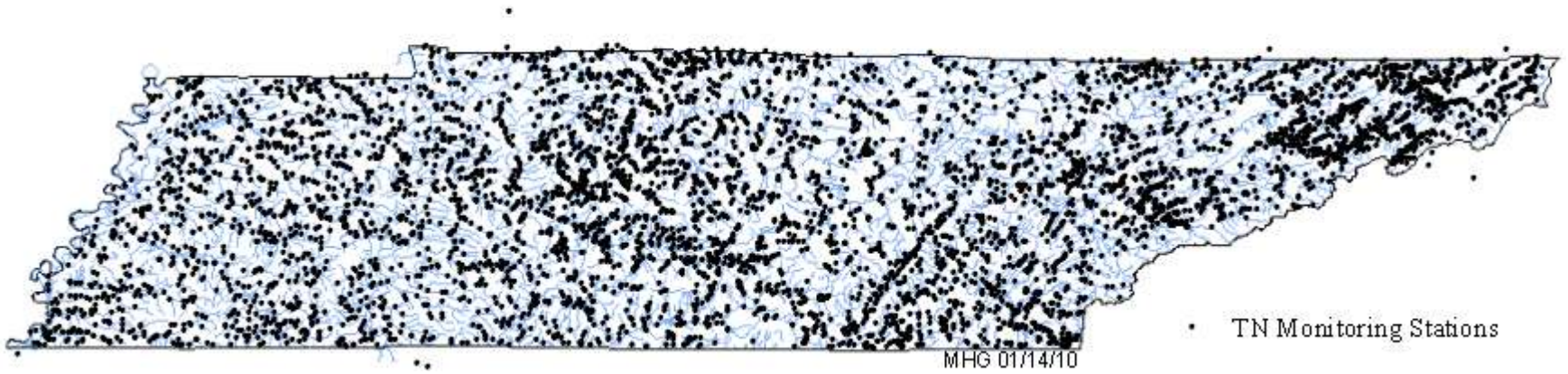


HUC	Watershed	Group	HUC	Watershed	Group	HUC	Watershed	Group
TN03150101	Conasauga River Watershed)	1	TN06010104	Holston River Watershed	4	TN06030004	Lower Elk River Watershed	2
TN05110002	Barren River Watershed	4	TN06010105	Upper French Broad Rv. Watershed	5	TN06030005	Pickwick Reservoir Watershed	2
TN05130101	Clear Fork Watershed	4	TN06010106	Pigeon River Watershed	5	TN06040001	Upper Kentucky Res. Watershed	3
TN05130103	Upper Cumberland Watershed	4	TN06010107	Lower French Broad Rv. Watershed	5	TN06040002	Upper Duck River Watershed	3
TN05130104	South Fork Cumberland Watershed	4	TN06010108	Nolichucky River Watershed	5	TN06040003	Lower Duck River Watershed	3
TN05130105	Obey River Watershed	4	TN06010201	Upper Tennessee River Watershed	4	TN06040004	Buffalo River Watershed	3
TN05130106	Cordell Hull Reservoir Watershed	4	TN06010204	Little Tennessee River Watershed	3	TN06040005	Lower Kentucky Res. Watershed	3
TN05130107	Collins River Watershed	2	TN06010205	Upper Clinch River Watershed	4	TN08010100	Mississippi River Watershed	5
TN05130108	Caney Fork River Watershed	2	TN06010206	Powell River Watershed	4	TN08010202	Lower Obion River Watershed	5
TN05130201	Old Hickory Reservoir Watershed	4	TN06010207	Lower Clinch River Watershed	3	TN08010203	South Fork Obion Rv. Watershed	5
TN05130202	Cheatham Reservoir Watershed	5	TN06010208	Emory River Watershed	1	TN08010204	North Forked Deer Rv. Watershed	2
TN05130203	Stones River Watershed	1	TN06020001	Lower Tennessee Watershed	3,4	TN08010205	South Forked Deer Rv. Watershed	1
TN05130204	Harpeth River Watershed	1	TN06020002	Hiwassee River Watershed	2	TN08010206	Forked Deer River Watershed	2
TN05130205	Barkley Reservoir Watershed	5	TN06020003	Ocoee River Watershed	1	TN08010207	Upper Hatchie River Watershed	4
TN05130206	Red River Watershed	4	TN06020004	Sequatchie River Watershed	5	TN08010208	Lower Hatchie River Watershed	4
TN06010101	North Fork Holston Rv. Watershed	3	TN06030001	Guntersville Reservoir Watershed	5	TN08010209	Loosahatchie River Watershed	2
TN06010102	South Fork Holston Rv. Watershed	2,3	TN06030002	Wheeler Reservoir Watershed	2	TN08010210	Wolf River Watershed	3
TN06010103	Watauga River Watershed	1	TN06030003	Upper Elk River Watershed	2	TN08010211	Nonconnah Creek Watershed	1

WPC 2010 Scheduled Monitoring Stations



Water Quality Monitoring Stations



Appendix D:

TESTS,

MINIMUM DETECTION LIMITS,

HOLDING TIMES,

CONTAINERS,

AND PRESERVATIVES

TDH Bacteriological Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Coliform, fecal		6 hours	Two 250 mL plastic, only 1 bottle is needed if only E.coli is analyzed. Bottles are sterilized.	Sodium Thiosulfate ($Na_2S_2O_3$). Bottles are labeled with preparation date and expiration date. Do not use expired bottles.
Coliform, total		30 hours		
E. coli		6 hours		

Store on ice $\leq$ 10°C.

TDH Routine Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Acidity	1 mg/L	14 days	1 liter plastic*	None
Alkalinity	10 mg/L	14 days		
Alkalinity, phen.	2 mg/L	14 days		
BOD, 5-day	2 mg/L	48 hours		
CBOD, 5-day	2 mg/L	48 hours		
Chloride	1 mg/L	28 days		
Chlorine, residual	0.1 mg/L	Test immed.		
Chromium, hexavalent	10 µg/L	24 hours		
Specific conductance	NA	28 days		
Fluoride	0.1 mg/L	28 days		
Nitrogen, nitrate	0.007mg/l	48 hours		
Nitrogen, nitrite	0.005 mg/L	48 hours		
Orthophosphate, total	0.01 mg/L	48 hours		
Oxygen, dissolved		Field		
pH		Field		
Silica	0.2 mg/L	28 days		
Sulfate	3.0 mg/L	28 days		
Turbidity	NA	48 hours		
MBAS	0.025 mg/L	48 hours	1 gallon plastic	
Color, apparent	5 Pt Co	48 hours		
Color, true	5 Pt Co	48 hours		
Residue, dissolved	10 mg/L	7 days		
Residue, suspended	10 mg/L	7 days		
Residue, settleable	0.1 ml/L	48 hours		
Residue, total	10 mg/L	7 days		

All plastics are one time use. Store on ice $\leq$6°C.

No preservative is needed for Routine Samples.

*If multiple analyses are needed, collect 1 gallon of sample to assure adequate volume is available for analyses and QC. Contact TDH Laboratory if assistance is needed to determine how much sample to collect.

TDH Nutrient Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
COD	5.0 mg/L	28 days	500 mL plastic	1 mL sulfuric acid (H_2SO_4)
Nitrogen, ammonia	0.03 mg/L	28 days		
Nitrogen, nitrate	0.007 mg/L	48 hours		
Nitrogen, NO_3 & NO_2	0.016 mg/L	28 days		
Nitrogen, total kjeldahl (TKN)	0.15 mg/L	28 days		
Nitrogen, total organic	0.15 mg/L	28 days		
Phosphorus, total	0.02 mg/L	28 days		

All plastics are one time use. Store on ice $\leq 6^oC$.
Powder free gloves must be worn with collecting nutrients.

TDH Metals Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Aluminum, Al	100 µg/L	6 months	1 liter plastic	5 mL 70% Nitric Acid (HNO_3)
Antimony, Sb	3 µg/L			
Arsenic, As	1 µg/L			
Barium, Ba	100 µg/L			
Beryllium, Be	1 µg/L			
Cadmium, Cd	1 µg/L			
Calcium, Ca	2 mg/L			
Chromium, Cr	1 µg/L			
Cobalt, Co	2 µg/L			
Copper, Cu	1 µg/L			
Iron, Fe	25 µg/L			
Lead, Pb	1 µg/L			
Magnesium, Mg	0.07 mg/L			
Manganese, Mn	5 µg/L			
Nickel, Ni	10 µg/L			
Potassium, K	0.3 mg/L			
Selenium, Se	2 µg/L			
Silver, Ag	1 µg/L			
Sodium, Na	0.1 mg/L			
Thallium, Tl	2 µg/L			
Vanadium, V	2 µg/L			
Zinc, Zn	1 µg/L			
Mercury, Hg (Nashville)	0.029 µg/L	28 days	1 liter plastic (same as above) or 500 mL plastic*	5.0 mL (for 1L bottle) or 2.5 mL (for 500mL bottle) 70% Nitric Acid (HNO_3)
Mercury, Hg (Jackson)	0.025 ug/L	28 days	1 liter plastic (same as above) or 500 mL plastic*	5.0 mL (for 1L bottle) or 2.5 mL (for 500mL bottle) 70% Nitric Acid (HNO_3)

All plastics are one time use. Store on ice $\leq 6^oC$.

Trace metals and low-level mercury samples are collected using the modified clean technique. * 500mL mercury bottle only need to be used for samples delivered to the Knoxville Lab or if mercury is the only metal that is being analyzed, otherwise, the 1-liter metals bottle is sufficient for mercury analysis.

TDH Miscellaneous Inorganic Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Cyanide	0.02 mg/L	14 days	1 liter plastic	pH>12; 5 mL of 50% sodium hydroxide ($NaOH_9$) at collection. 0.6 g ascorbic acid ($C_6H_8O_6$) if KI paper indicates chlorine.
Oil & Grease	5 mg/L	28 days	1 liter glass, wide mouth with Teflon® lined lid	2 mL sulfuric acid (H_2SO_4)
Phenols, total	10 µg/L	28 days	1 liter glass, amber	2 mL sulfuric acid (H_2SO_4)
Sulfide	1 mg/L	7 days	500 mL glass	2 mL zinc acetate (ZnAc) in laboratory. 5 mL 50% sodium hydroxide (NaOH) in field.
Boron	200 µg/L	6 months	125 mL plastic	0.75 mL hydrochloric acid (HCl)
Flash Point		None specified	16-ounce glass Teflon® lined lid	None
TCLP		28 days	16-ounce glass jar*	None
TOC	0.1 mg/L	28 days	Three 40 ml vials. A fourth vial is required for QC on site for each sampling run	0.1 ml phosphoric acid (H3PO4)

All plastics are one time use. Store on ice $\leq 6^{o}C$.
*Due to analysis requirements , this could require much more sample (Protocol C *QSSOP Chemical and Bacteriological Sampling of Surface Waters* (2009).

TDH Organic Analyses Available

Test	Required MDL	Holding Time	Container	Preservative
Base/Neutral/Acid Extractables				
NPDES Extrac.		7 days to extract; 40 days to analyze	One 1-gallon amber bottle, acetone-rinsed, and Teflon®-lined cap.	None
Pesticides/PCBs				
TAL Extrac.				
Nitrobodies				
Semivolatiles				
Volatiles and Petroleum Hydrocarbons				
NPDES Volatiles		14 days	Five 40-mL amber vials, Teflon®-lined septa caps, no headspace.	1:1 hydrochloric acid (HCl)
TAL Volatiles				
BTEX		14 days	Five 40-mL amber	1:1 hydrochloric acid (HCl)

GRO			vials, Teflon®-lined septa caps, no headspace	
EPH		14 days	One 1-gallon amber bottle with Teflon® lined lid	1:1 Hydrochloric Acid (HCl)

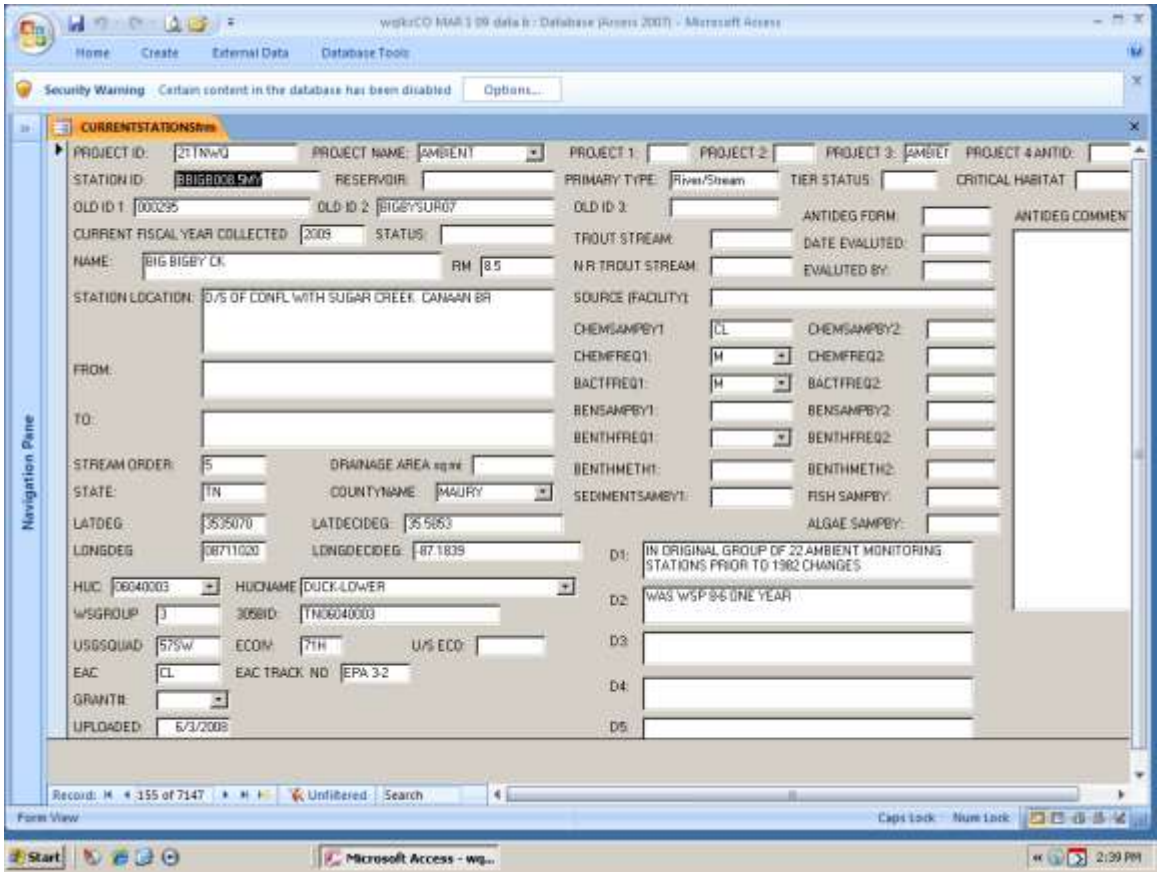
Store on ice $\leq 6^{o}C$.

The TDH Environmental Laboratory is contacted for collection instruction for other types of analyses.

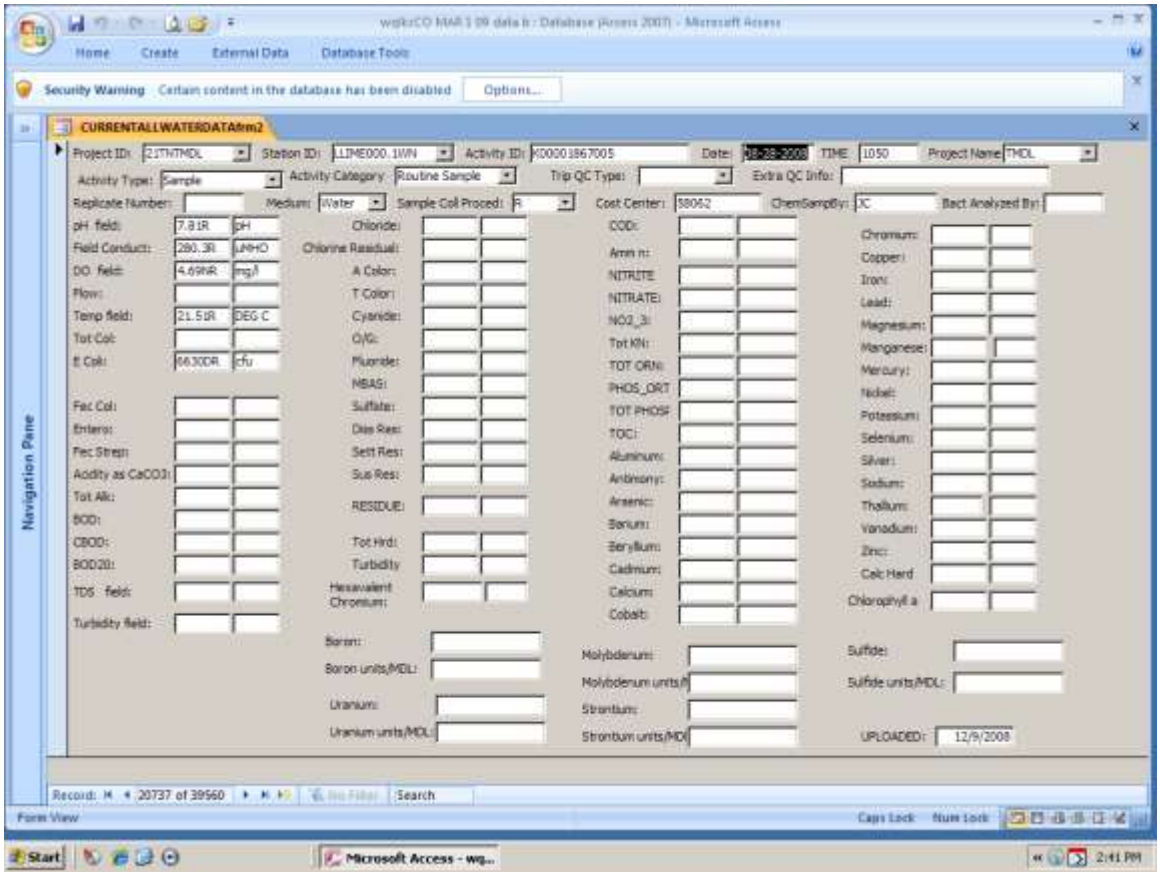
Appendix E:

DATA ENTRY FORMS

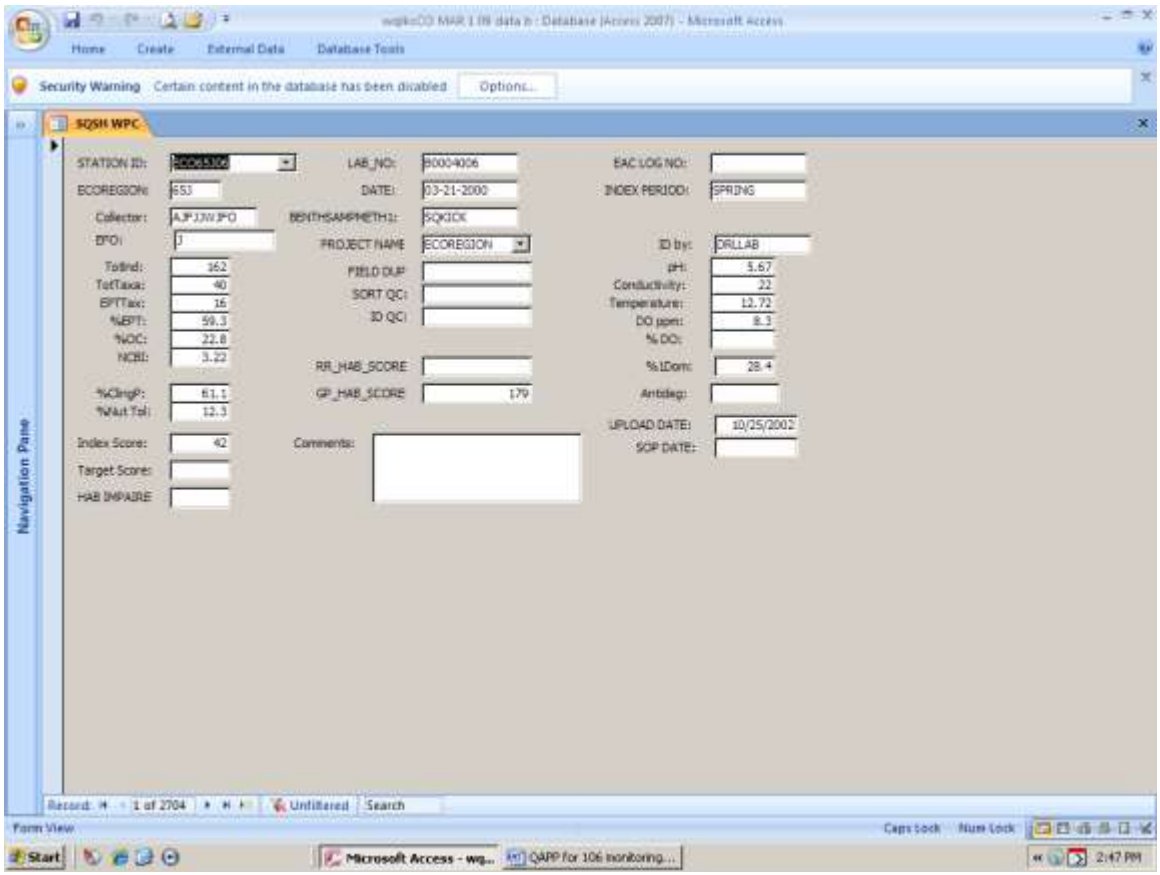
WQDB Station Entry Form



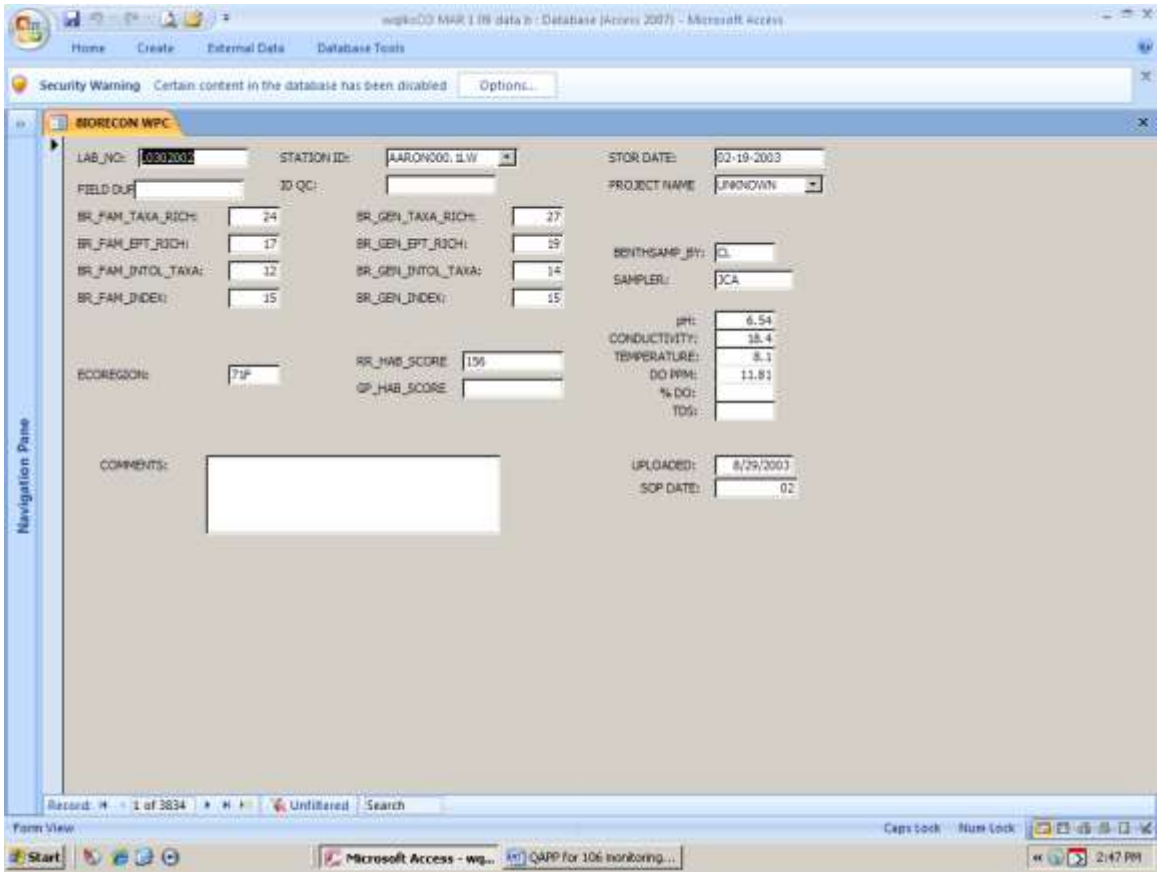
WQDB Chemical and Bacteriological Results Entry Form



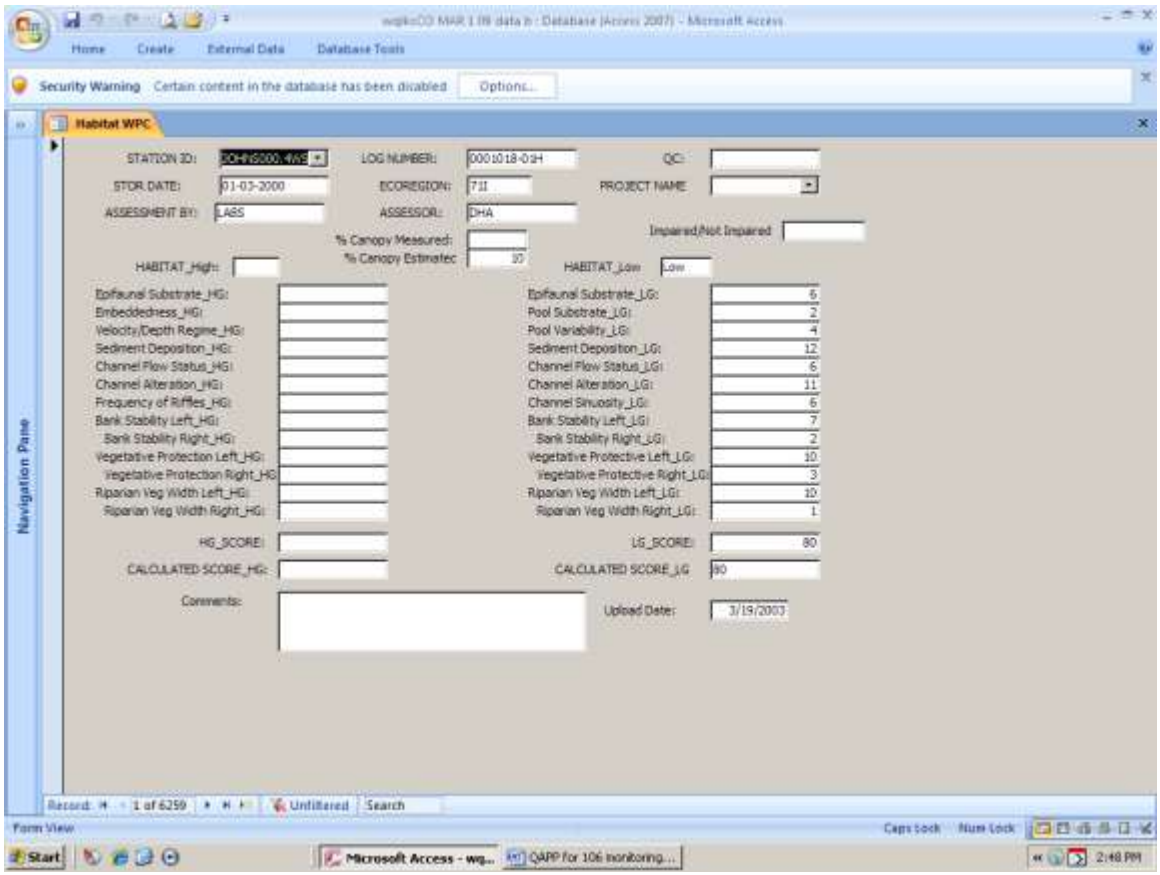
WQDB Semi-Quantitative Single Habitat Entry Form



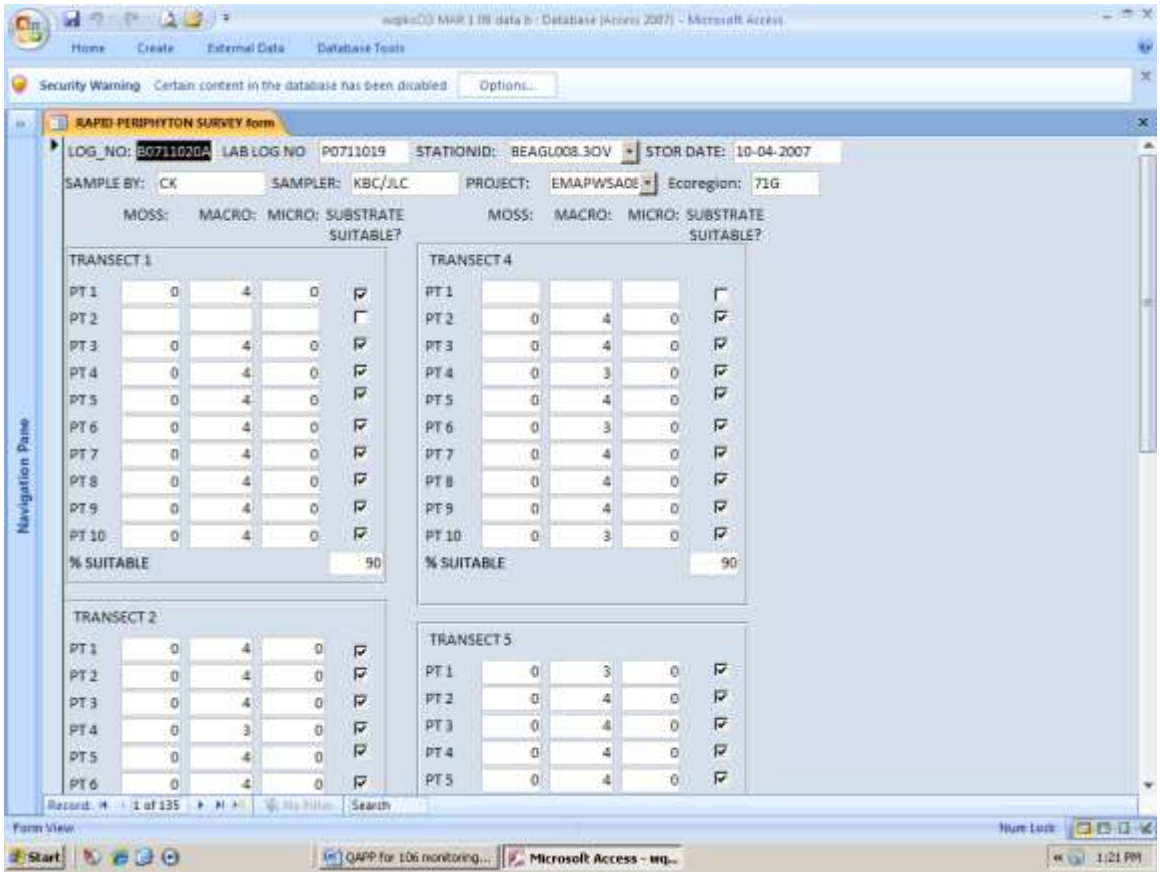
WQDB Biorecon Results Entry Form



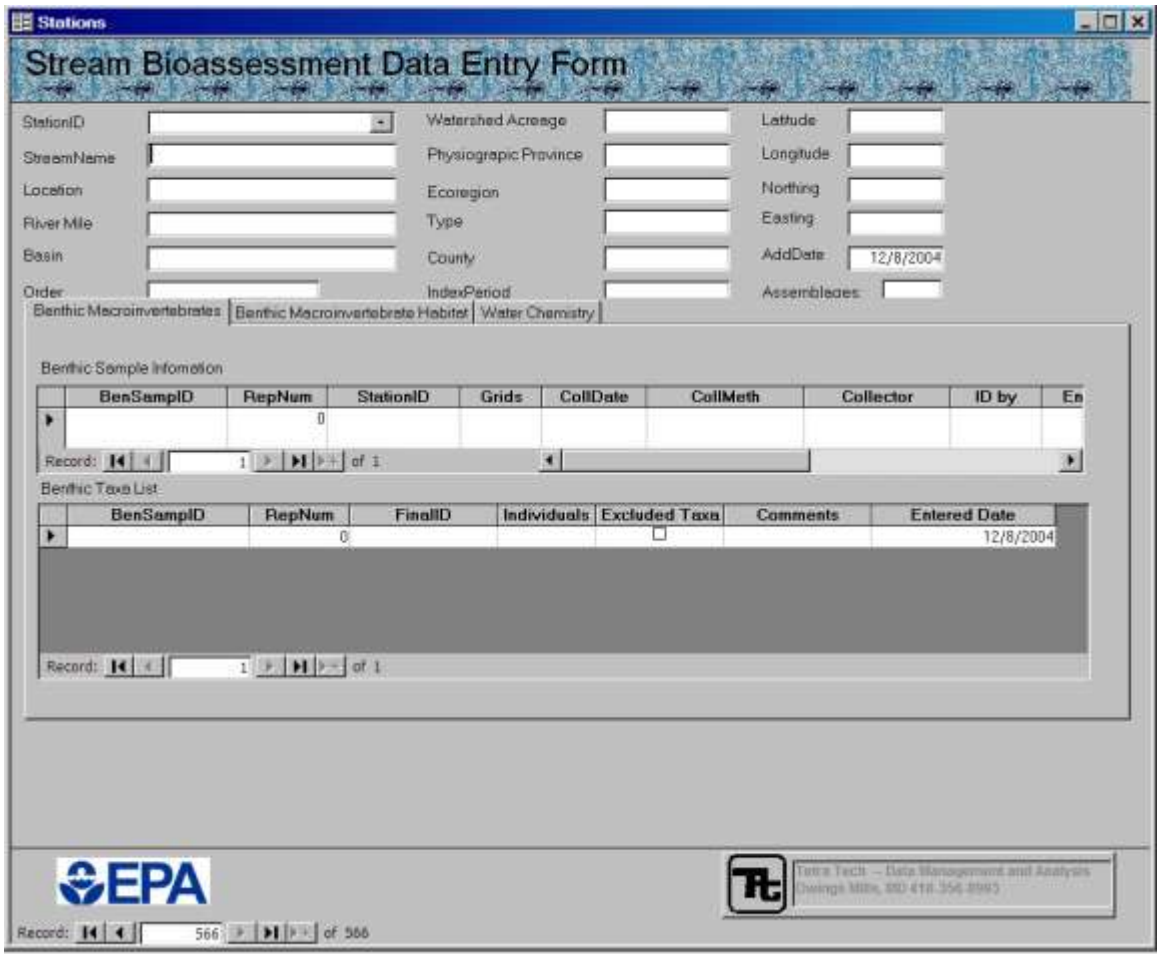
WQDB Habitat Assessment Entry Form



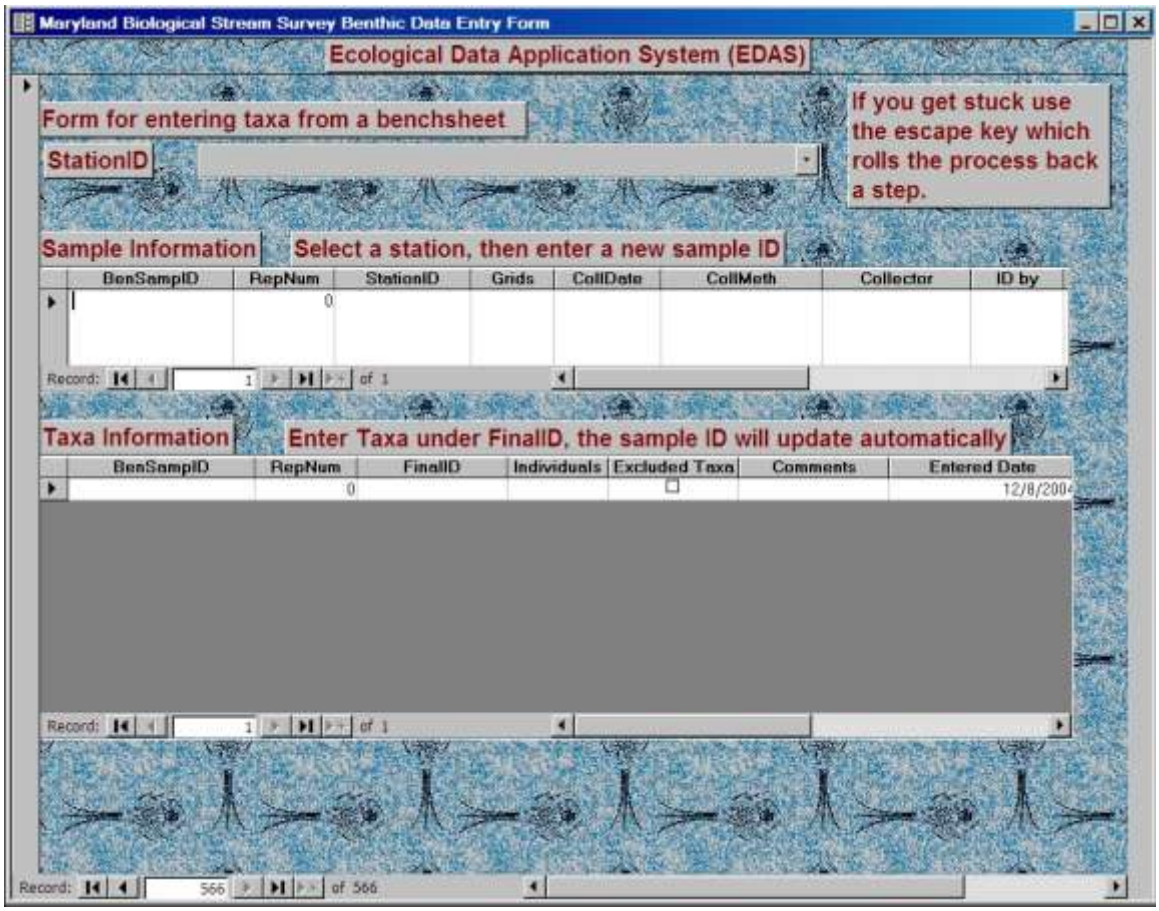
WQDB Rapid Periphyton Survey Form



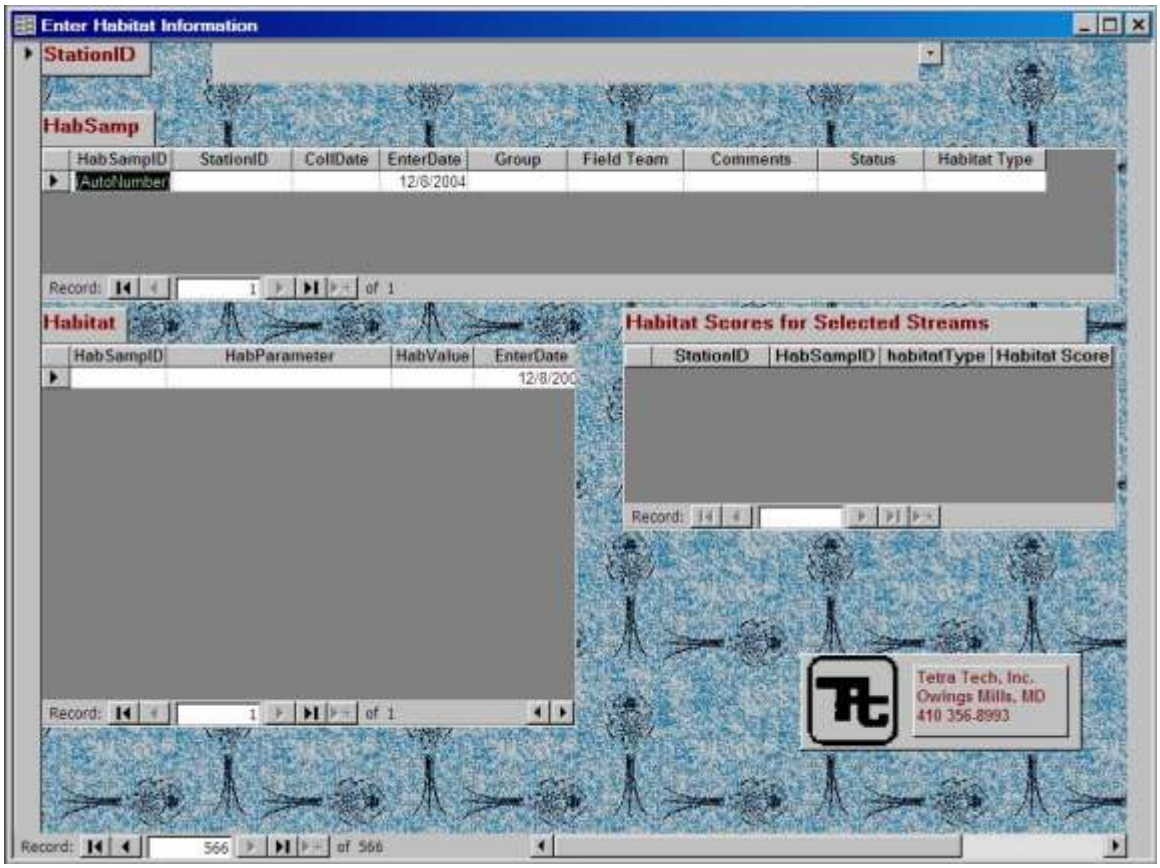
SQDATA Station Entry Form



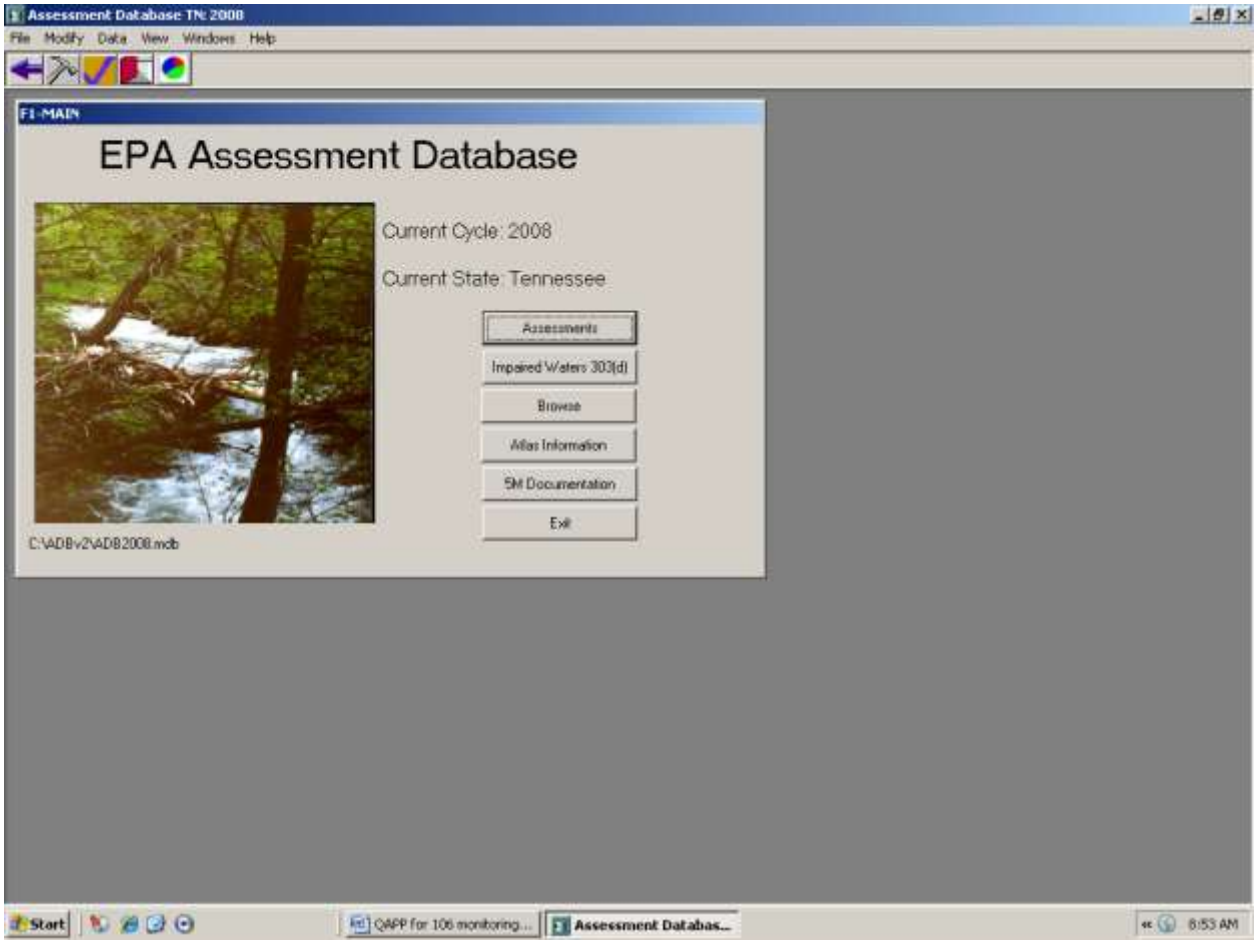
SQDATA Semi-Quantitative Single Habitat Entry Form



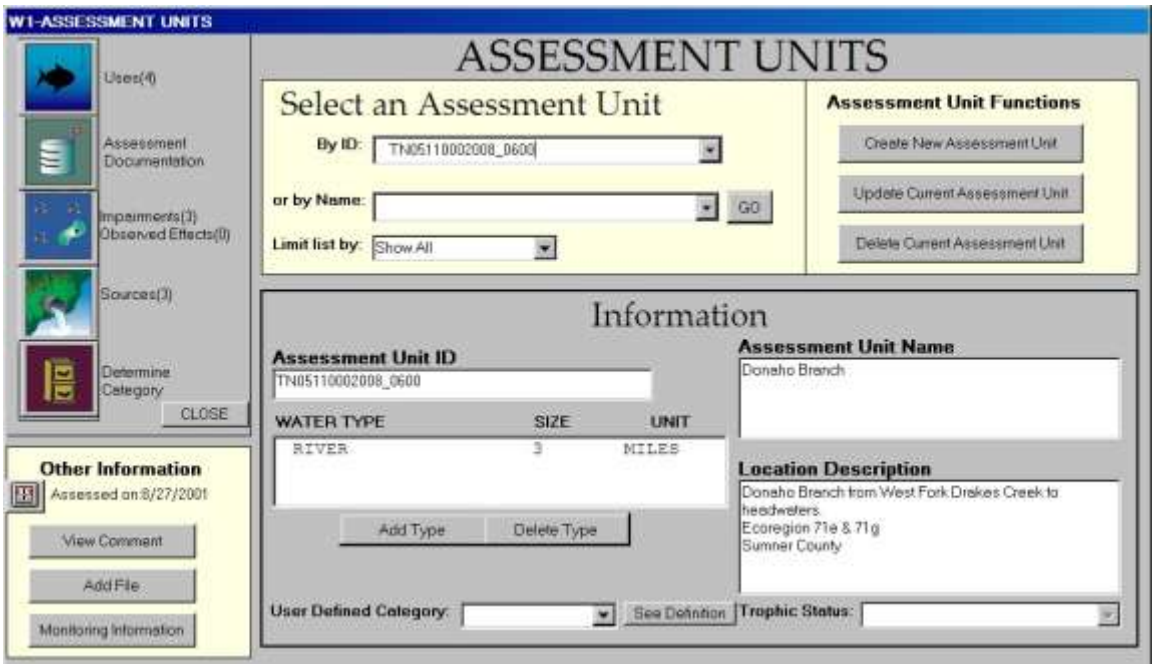
SQDATA Habitat Assessment Entry Form



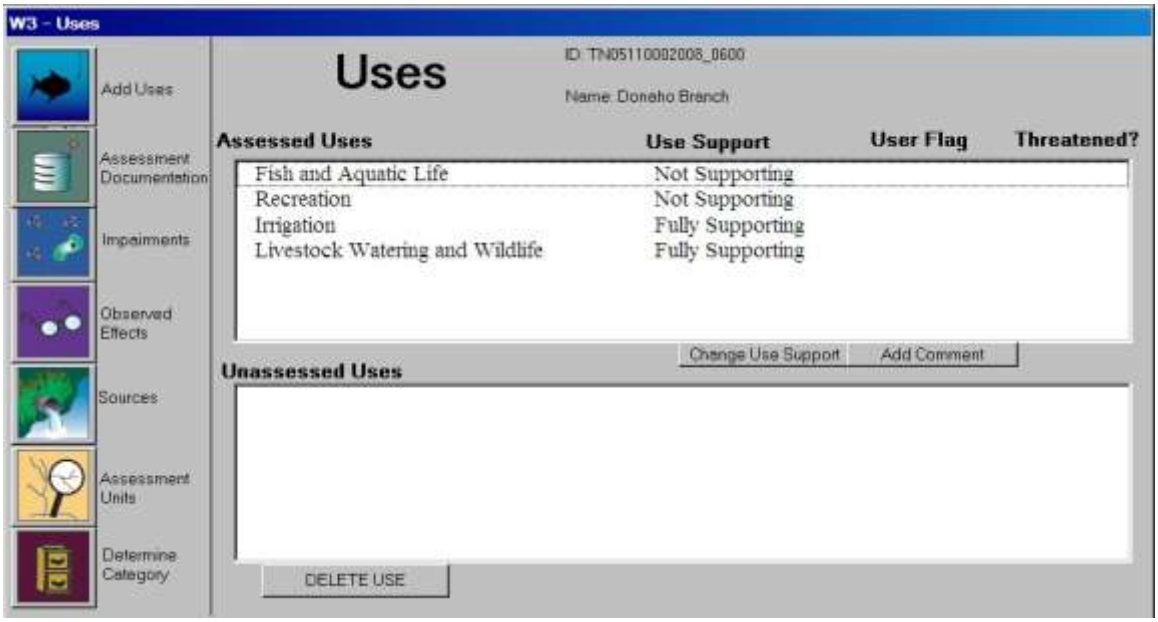
ADB Entry Page



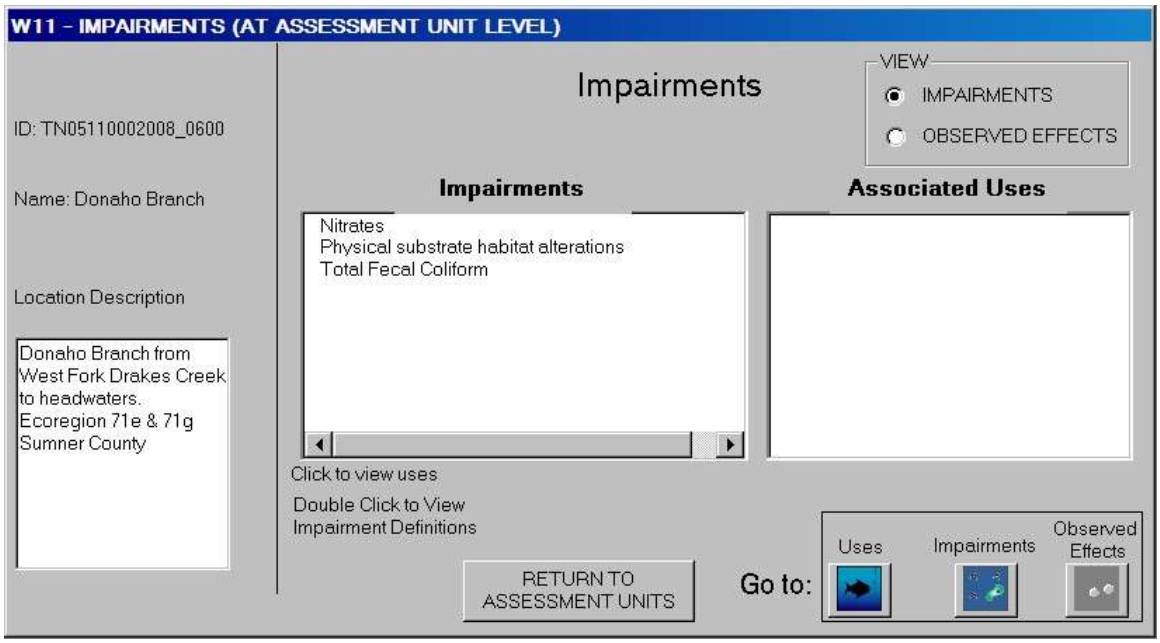
ADB Assessment Units Page



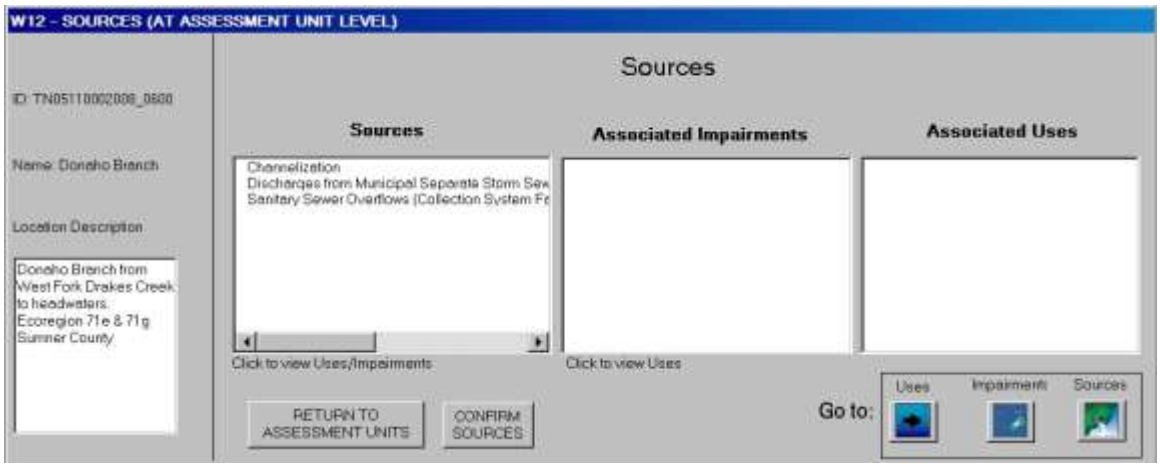
ADB Classified Uses Page



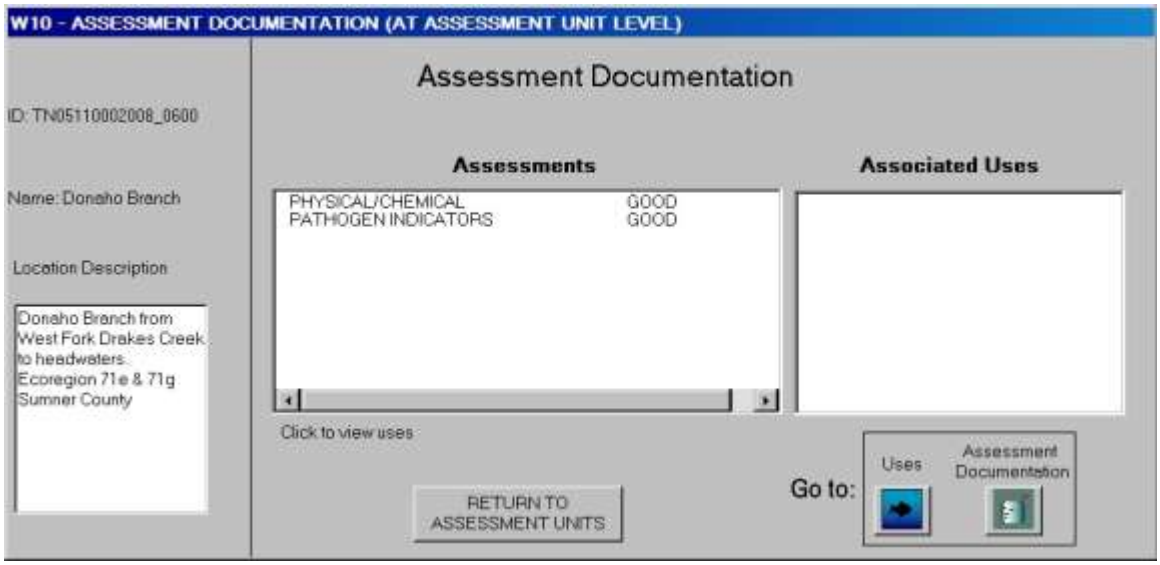
ADB Impairment Causes Page



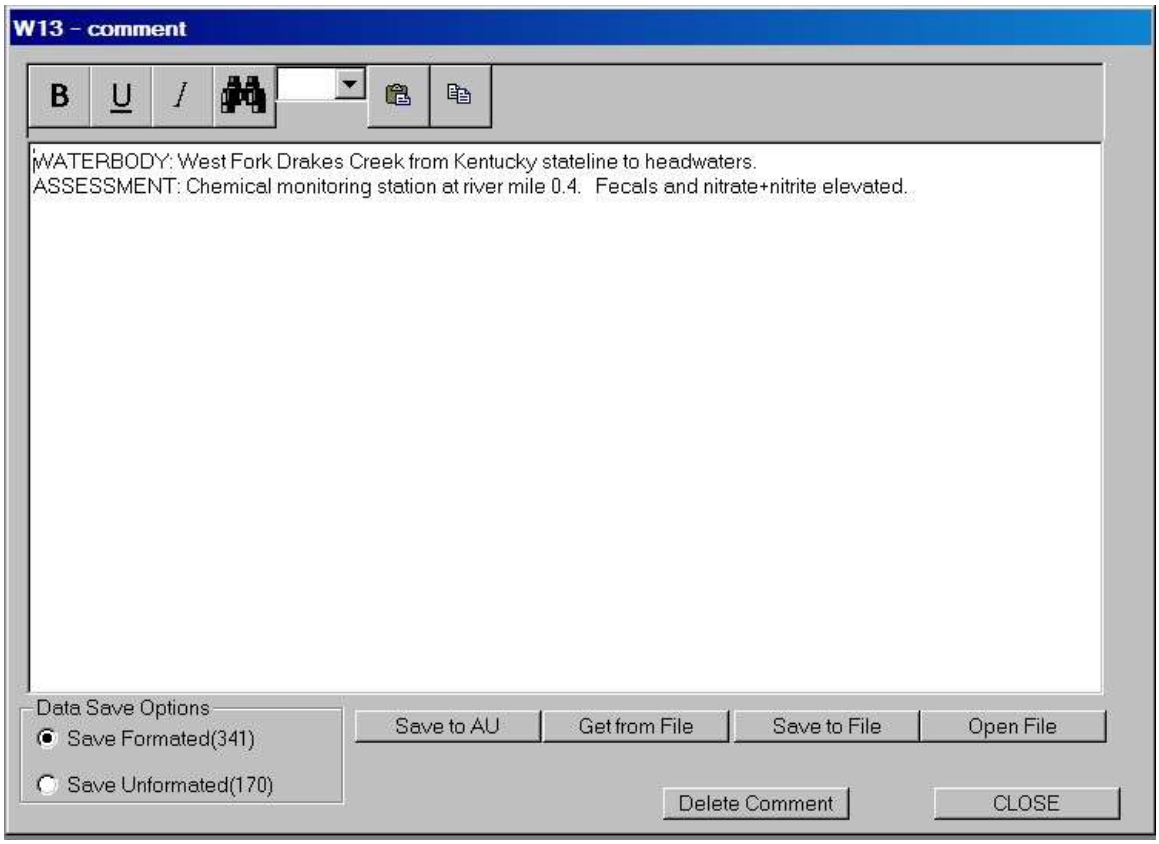
ADB Impairment Sources Page



ADB Assessment Documentation Page



ADB Comment Page



Appendix F

AUDIT REPORTS

Environmental Field Office Monitoring Audit Report

Front

EFO	Date		
Fiscal Year Watershed Group	Auditor		
In-house Chemical/Bacteriological QC Officer	In-house Biological QC Officer		
Are current versions of the following documents accessible to all samplers?			
• WPC Monitoring & Assessment Program Plan (TDEC, FY 2009)	Yes □	No □	Comments_____
• QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2006)	Yes □	No □	Comments_____
• QSSOP for Chemical and Bacteriological Sampling (TDEC, 2009)	Yes □	No □	Comments_____
• QSSOP for Peripyhton Sampling (TDEC, 2010)	Yes □	No □	Comments_____
• 303(d) List (TDEC, 2008)	Yes □	No □	Comments_____
• Rules of TDEC-TWQCB-WPC Chapters 1200-4-3 & 1200-4-4 (WQCB, 2007)	Yes □	No □	Comments_____
• MSDS available for ethanol, nitric acid, sulfuric acid, hydrochloric acid, and any other chemical or preservatives present in EFO?	Yes □	No □	Comments_____
Are the following databases available to all samplers?			
• Assessment Database (ADB)	Yes □	No □	Comments_____
• Water Quality Database (WQDB)	Yes □	No □	Comments_____
• TN's Online Water Quality Assessment	Yes □	No □	Comments_____
Do samplers know how to use them?	Yes □	No □	Comments_____
Are SOPs being followed for sample handling?	Yes □	No □	Comments
Are deviations from SOPs being documented?	Yes □	No □	Comments
Are sampling priorities specified in Program plan being met?	Yes □	No □	Comments
Is a list of needed analyses/site available?	Yes □	No □	Comments
Chemical/Bacteriological Sample Collections			
• Is Chain of Custody being maintained?	Yes □	No □	Comments
• Are custody seals being used on coolers?	Yes □	No □	Comments
• Are QC samples (Duplicate, Trip and Field Blanks) collected at 10% of sites?	Yes □	No □	Comments
• Are gloves being worn for collection of nutrient samples?	Yes □	No □	Comments
• Are sterile sampling devices being used to collect bact. samples?	Yes □	No □	Comments
• Is proper field cleaning procedure being used for reusable equipment?	Yes □	No □	Comments
• Are samples being delivered to TDH Lab within holding time?	Yes □	No □	Comments
Water Parameter Probes			
• Are field water parameter probes working properly?	Yes □	No □	Comments
• Are calibration standards available and used?	Yes □	No □	Comments

• Are chemicals stored properly?	Yes □	No □	Comments
• Are pre calibrations and post drift checks being performed each day of use?	Yes □	No □	Comments
• Is calibration logbook maintained?	Yes □	No □	Comments
Flow Meters			
• Are flow meters working properly?	Yes □	No □	Comments
• Are pre calibrations and post drift checks being performed each day of use?	Yes □	No □	Comments
• Is calibration logbook maintained?	Yes □	No □	Comments
• Are flow measurements being sent to PAS?	Yes □	No □	Comments
Biological			
• Are QC duplicate biological samples collected at 10% of sites?	Yes □	No □	Comments
• Are biological samples logged-in?	Yes □	No □	Comments
• Are 10% biological samples id'ed in EFO QC'ed?	Yes □	No □	Comments
• Are 10% of SQSH sorting in EFO QC'ed?	Yes □	No □	Comments
• Are QC results recorded in a logbook?	Yes □	No □	Comments
• Are all biological and habitat assessments and field data being sent to PAS?	Yes □	No □	Comments
• Are field water parameters recorded when biological samples are collected?	Yes □	No □	Comments
Data Management			
• Are watershed files accessible?	Yes □	No □	Comments
• Are station Ids being assigned to all sampling locations?	Yes □	No □	Comments
• Are station Ids sent to PAS before analyses results are received?	Yes □	No □	Comments
Bacteriological Analyses			
• Is sterile water used for IDEXX Quanti-Tray®/2000 dilutions? NA□	Yes □	No □	Comments
• Are sterile containers used for analyses? NA□	Yes □	No □	Comments
• Are 10% QC samples being run? NA□	Yes □	No □	Comments
• Is pathogen log being maintained? NA□	Yes □	No □	Comments
• Are bacteriological data from EFO, contractor, or univ. sent to PAS?	Yes □	No □	Comments

Issues of Concern:

Auditor Signature	Date	EFO Manager Signature	Date
In-house Chemical/Bacteriological QC Officer	Date	In-house Biological QC Officer	Date

Chemical and Bacteriological Results Verification Audit Form